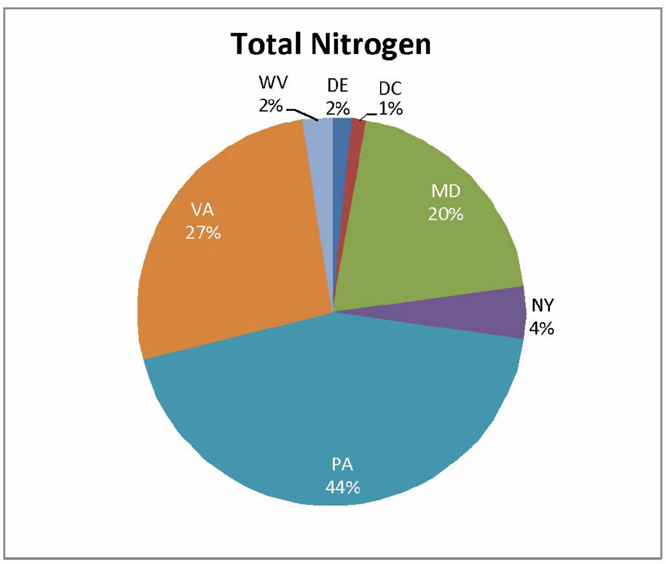
SECTION 4. SOURCES OF NITROGEN, PHOSPHORUS AND SEDIMENT TO THE CHESAPEAKE BAY

Nitrogen, phosphorus, and sediment loads originate from many sources in the Bay watershed. Point sources of nitrogen, phosphorus, and sediment include municipal wastewater facilities, industrial discharge facilities, CSOs, SSOs, NPDES permitted stormwater (MS4s and construction and industrial sites), and CAFOs. Nonpoint sources include agricultural lands (AFOs, cropland, hay land, and pasture), atmospheric deposition, forest lands, on-site treatment systems, nonregulated stormwater runoff, streambanks and tidal shorelines, tidal resuspension, the ocean, wildlife, and natural background. Unless otherwise specified, the loading estimates presented in this section are based on results of the Phase 5.3 Chesapeake Bay Watershed Model (Bay Watershed Model). For a description of the Bay Watershed Model, see Section 5.8. Estimates of existing loading conditions are based on the 2009 scenario run through the Bay Watershed Model.

4.1 JURISDICTION LOADING CONTRIBUTIONS

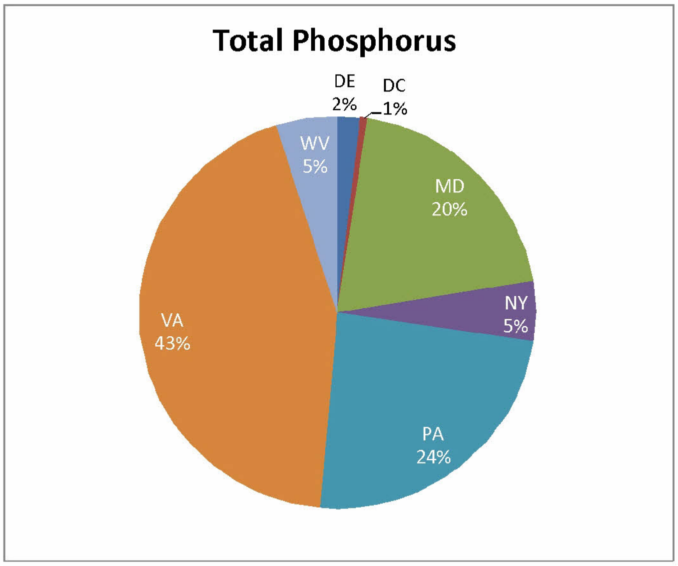
Analysis of 2009 monitoring data and estimated modeling results shows that Pennsylvania provided the largest proportion of nitrogen loads delivered to the Bay (44 percent), followed by Virginia (27 percent), Maryland (20 percent), New York (4 percent), Delaware (2 percent) and West Virginia (2 percent), and the District of Columbia (1 percent) (Figure 4-1). Delivered loads are the amount of a pollutant delivered to the tidal waters of the Chesapeake Bay or its tributaries from an upstream point. Delivered loads differ from edge-of-stream loads becauese of in-stream processes in free-flowing rivers that naturally remove nitrogen and phosphorus from the system.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-1. Modeled estimated total nitrogen loads delivered to the Chesapeake Bay by jurisdiction in 2009.

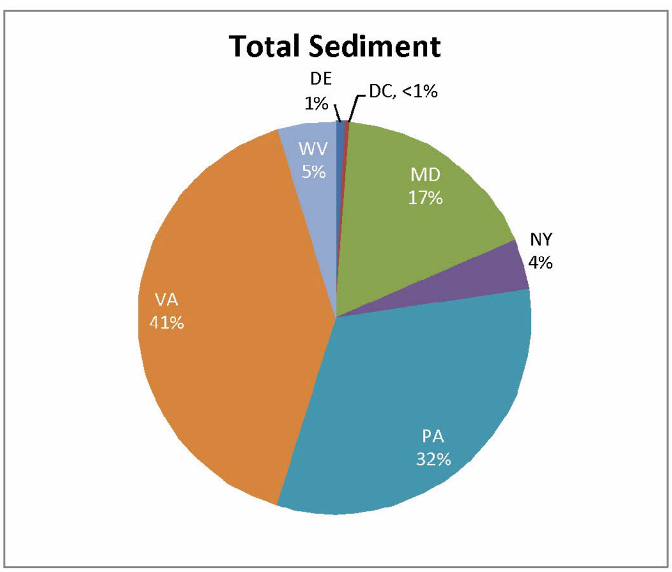
The model estimated phosphorus loads delivered to the Bay were dominated by Virginia (43 percent), followed by Pennsylvania (24 percent), Maryland (20 percent), New York (5 percent), West Virginia (5 percent), Delaware (2 percent), and the District of Columbia (1 percent) (Figure 4-2).



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-2. Model estimated total phosphorus loads delivered to the Chesapeake Bay by jurisdiction in 2009.

Similar to the phosphorus loads, 2009 model estimated sediment loads delivered to the Bay are dominated by Virginia (41 percent), followed by Pennsylvania (32 percent), Maryland (17 percent), West Virginia (5 percent), New York (4 percent), Delaware (1 percent), and the District of Columbia (< 1 percent) (Figure 4-3).

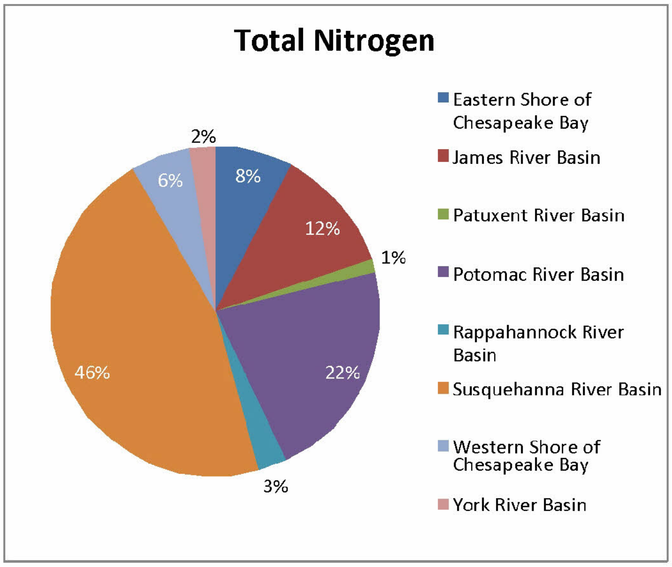


Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-3. Model estimated total sediment loads delivered to the Chesapeake Bay by jurisdiction in 2009.

4.2 MAJOR RIVER BASIN CONTRIBUTIONS

The major river basins' model-estimated contributions of total nitrogen loads delivered to the Bay in 2009 are illustrated in Figure 4-4. The Susquehanna River basin, draining parts of New York, Pennsylvania, and Maryland, is estimated to be responsible for almost half of the nitrogen loads delivered to the Bay (46 percent). The next major contributor, at 22 percent, is the Potomac River Basin, draining the entire District of Columbia and parts of Maryland, Pennsylvania, Virginia, and West Virginia. The James River Basin (draining parts of Virginia and West Virginia) contributes 12 percent of the nitrogen loads to the Bay; the Eastern Shore Basin (draining parts of Delaware, Maryland, and Virginia) contibutes 8 percent of the nitrogen loads to the Bay; and the Western Shore Basin (draining parts of Maryland) is estimated to be responsible for 6 percent of the nitrogen loading to the Bay. Smaller portions, 3 percent, 2 percent, and 1 percent are contributed by the Rappahannock (Virginia), the York (Virginia) and the Patuxent (Maryland) river basins, respectively (Figure 4-4).

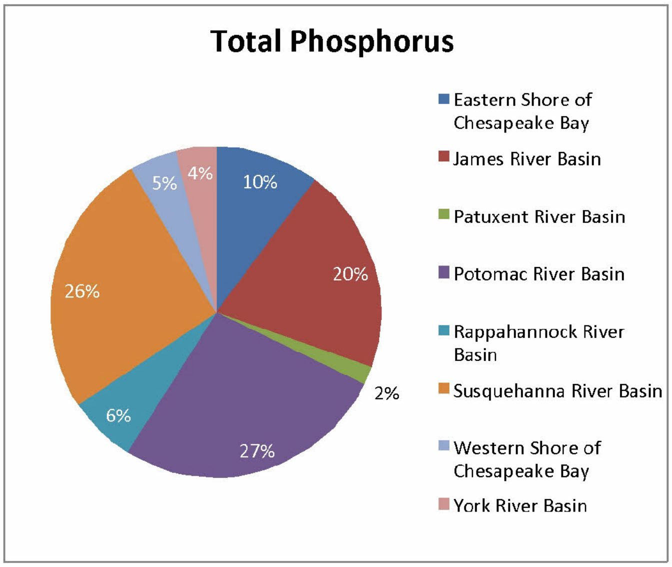


Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-4. Model estimated total nitrogen loads delivered to the Chesapeake Bay by major tributary in 2009.

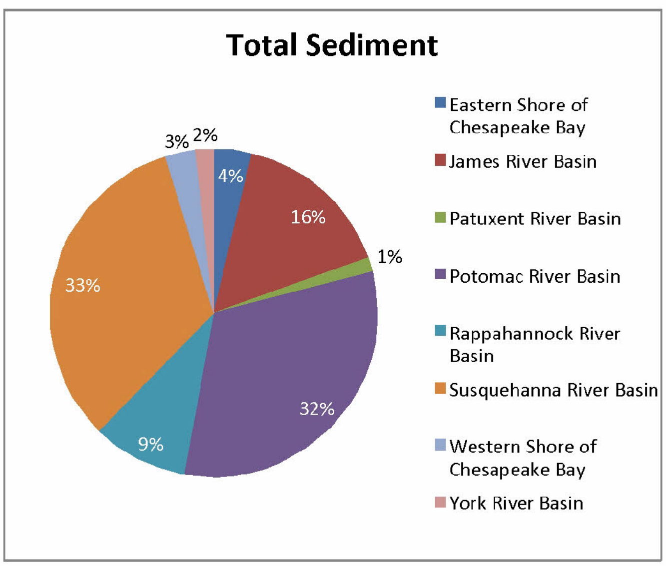
The major river basins' model estimated contributions to total phosphorus loads to the Bay in 2009 are illustrated in Figure 4-5. Three river basins—the Potomac (27 percent), the Susquehanna (26 percent), and the James (20 percent)—are estimated to account for about three-quarters of the total phosphorus loading to the Bay. The Eastern Shore contributes 10 percent of the total phosphorus load, while the balance is provided by the Rappahannock (6 percent), the Western Shore (5 percent), the York (4 percent), and the Patuxent (2 percent) river basins (Figure 4-5).

The major river basins' model estimated contributions to total sediment loads to the Bay in 2009 are illustrated in Figure 4-6. The Susquehanna (33 percent) and Potomac (32 percent) river basins are estimated to contribute the majority of the total sediment loads delivered to the Chesapeake Bay, followed by the James (16 percent) and the Rappahannock (9 percent) river basins. The Eastern Shore (4 percent), Western Shore (3 percent), York (2 percent) and Patuxent (1 percent) river basins each contribute relatively small total sediment loads (Figure 4-6).



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-5. Model estimated total phosphorus loads delivered to the Chesapeake Bay by major tributary in 2009.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-6. Model estimated total sediment loads delivered to the Chesapeake Bay by major tributary in 2009.

4.3 POLLUTANT SOURCE SECTOR CONTRIBUTIONS

Table 4-1 and Table 4-2 provide model estimates of major pollutant sources of nitrogen and phosphorus, respectively, delivered to the Bay by each jurisdiction and by each major pollutant source sector. Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters (e.g., streams, rivers). Table 4-3 provides estimates of major sediment sources by jurisdiction and by major pollutant source sector and represents the portion of sediment that is from land-based sources. Stream erosion is also a significant source of watershed sediment delivered to the Bay. Sufficient data do not exist to accurately quantify the portion of the total sediment load specifically from stream erosion.

Table 4-1. Percentage of total nitrogen delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	3%	1%	1%	0%	2%	1%
District of Columbia	0%	0%	1%	5%	0%	0%
Maryland	16%	14%	28%	27%	36%	27%
New York	4%	7%	3%	3%	5%	5%
Pennsylvania	55%	46%	33%	25%	30%	42%
Virginia	20%	27%	33%	39%	24%	25%
West Virginia	3%	4%	2%	1%	2%	1%
Total	100%	100%	100%	100%	100%	100%

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters.

Table 4-2. Percentage of total phosphorus delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	4%	1%	1%	0%	0%	0%
District of Columbia	0%	0%	1%	2%	0%	0%
Maryland	19%	14%	28%	21%	0%	27%
New York	5%	7%	3%	5%	0%	5%
Pennsylvania	24%	25%	16%	28%	0%	27%
Virginia	42%	45%	50%	42%	0%	38%
West Virginia	6%	7%	2%	3%	0%	2%
Total	100%	100%	100%	100%	100%	100%

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Nontidal deposition refers to atmospheric deposition direct to nontidal surface waters. Although the percentage contribution of phosphorus from nontidal deposition is provided here, the overall amount of phosphorus contributed from nontidal deposition is considered to be insignificant.

Table 4-3. Percentage of sediment delivered to the Bay from each jurisdiction by pollutant source sector

Jurisdiction	Agriculture	Forest	Stormwater runoff	Point source	Septic	Nontidal deposition
Delaware	1%	0%	1%	0%	--	--
District of Columbia	0%	0%	1%	27%	--	--
Maryland	15%	13%	32%	11%	--	--
New York	3%	8%	4%	3%	--	--
Pennsylvania	35%	34%	21%	23%	--	--
Virginia	41%	40%	39%	35%	--	--
West Virginia	5%	5%	3%	1%	--	--
Total	100%	100%	100%	100%	--	--

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Only land-based sources of sediment were included in this table. Septic sources discharge to groundwater and nontidal deposition refers to atmospheric deposition direct to nontidal surface waters.

The following sections provide additional details regarding the major pollutant source sectors, including descriptions of the extent/magnitude of the pollutant source, geographic distribution, and long-term trends relevant to the source sector. The significance of the source sector in terms of loading to the Bay relative to other sources is also discussed.

4.4 REGULATED POINT SOURCES

Point sources are defined as any "discernable, confined, and discrete conveyance, including...any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, or vessel or other floating craft, from which pollutants are or may be discharged" [CWA section 502(14), 40 CFR 122.2]. That definition does not include agricultural stormwater discharges or return flows from irrigated agriculture, which are exempt from the definition of point source under the CWA. The NPDES program, under CWA sections 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

Two issues that directly affect modeling of the regulated point sources in the Bay watershed are the size of facility flows and permitted discharge limits. For purposes of the Chesapeake Bay TMDL analysis and modeling, regulated point sources in the Chesapeake Bay watershed have been evaluated under the following categories[1]:

- Municipal wastewater facilities
- Industrial wastewater facilities
- CSOs
- NPDES permitted stormwater (MS4s, industrial, and construction)
- NPDES permitted CAFOs

[1] The universe of regulated point sources may change over time due to such actions as designation, compliance evaluation, or new permitting activities.

The remainder of this section outlines the distinctions between significant and nonsignificant municipal and industrial wastewater discharge facilities in the Bay watershed, explains how the facilities were addressed in modeling, discusses the effect of the basinwide nitrogen and phosphorus permitting approach on point source modeling for the TMDL, and provides a summary of model-estimated loads associated with each of the regulated point source categories of nitrogen, phosphorus, and sediment to the Bay. Appendix Q includes the regulated point sources accounted for in the Bay TMDL.

4.4.1 Significant and Nonsignificant Municipal and Industrial Facilities

Municipal and industrial wastewater discharge facilities are categorized as significant or nonsignificant primarily on the basis of permitted or existing flow characteristics and comparable loads in the case of industrial discharge facilities. The Bay jurisdictions define significant facilities as outlined in Table 4-4.

Table 4-4. Jurisdiction-specific definitions of significant municipal and industrial wastewater discharge facilities

Jurisdiction	Municipal wastewater facilities (million gallons per day)	Industrial wastewater facilities (estimated loads, pounds per year)
Delaware	Design flow ≥ 0.4	≥ 3,800 total phosphorus or ≥ 27,000 total nitrogen
District of Columbia	Blue Plains WWTP	
Maryland	Design flow ≥ 0.5	
New York	Design flow ≥ 0.4	
Pennsylvania	Existing flow ≥ 0.4	
Virginia	Design flow ≥ 0.5[a] Design flow ≥ 0.1[b] New facilities ≥ 0.04[c]	
West Virginia	Design flow ≥ 0.4	

Source: USEPA 2010b
Notes: a. Above the fall line/tidal line; b. Below the fall line/tidal line; c. Also includes expansion of flows ≥ 0.04 mgd.

Jurisdictions also may identify specific facilities as significant in their WIPs (USEPA 2009c). Facilities not meeting the above criteria, and not otherwise identified in the jurisdictions' WIPs, are considered nonsignificant facilities. Table 4-5 provides a jurisdictional breakdown of municipal and industrial discharging facilities in the Chesapeake Bay watershed.

For the TMDL, facilities were represented using various flow and discharge concentrations depending on their status as significant or nonsignificant. Significant facilities received individual WLAs, except for New York and the Virginia James River Basin, which received an aggregate WLA. The New York WLA for wastewater is discussed further in Section 8.4.4, and the James River Basin WLA is discussed further in Appendix X. Nonsignificant facilities were generally included in the aggregate WLAs by Bay segment watershed (USEPA 2009c) and are discussed further in Section 8.3.3.

Table 4-5. Significant and nonsignificant municipal and industrial wastewater discharging facilities by jurisdiction as of December 2010

Jurisdiction	Significant facility			Nonsignificant facility			Total Facilities
	Municipal	Industrial	Total	Municipal	Industrial	Total	
DC[a]	1	0	1	1	9	10	11
DE	3	1	4	1	1	2	6
MD	75	12	87	163	477	640	727
NY	26	2	28	26	45	71	99
PA	183	30	213	1246	409	1655	1868
VA	101	24	125	1618	639	2257	2382
WV[b]	13	7	20	125	23	148	168
Total	**402**	**76**	**478**	3180	1603	4783	5261

Source: Facilities identified in the final phase 1 WIPs
Notes:
a. Blue Plains WWTP serves DC and parts of MD and VA, but is only counted once.
b. Multiple facilities (4) share one NPDES permit in West Virginia.

4.4.2 Basinwide NPDES Permitting Approach

In 2004 EPA and the Bay watershed jurisdictions agreed to take a consistent approach to permitting all the significant municipal and industrial wastewater discharging facilities contributing nitrogen and phosphorus to the Chesapeake Bay watershed (USEPA 2004d). As part of that approach and on the basis of the jurisdictions' revised Chesapeake Bay WQS, permits are to be reissued with nitrogen and phosphorus limits that are sufficient to achieve Bay WQS and that are consistent with the jurisdictions' tributary strategies. The basinwide permitting approach also contains additional specific provisions for permitting of nitrogen and phosphorus in the Bay watershed, including the following:

- Annual load limits—Unless such expressions would be impracticable, EPA's regulations require NPDES permits for non-publicly owned treatment works to express effluent limits as maximum daily and average monthly limits [40 CFR 122.45(d)(1)] and require NPDES permits for POTWs to express effluent limits as average weekly and average monthly limits [40 CFR 122.45(d)(2)]. In the case of the Chesapeake Bay permitting for nitrogen and phosphorus, EPA has determined that because of the long hydraulic durations in the Bay, and the fact that the control of annual loading levels of nitrogen and phosphorus from wastewater treatment plants is much more relevant and appropriate in terms of the effect of nitrogen and phosphorus on Bay water quality criteria than daily maximums or weekly or monthly averages, expression of nitrogen and phosphorus effluent limits in short periods is impracticable and that, therefore, such effluent limits may be expressed as an annual load (USEPA 2004c).
- Compliance Schedules—Compliance schedules that are consistent with jurisdiction tributary strategies may be incorporated into permits, where such compliance schedules are needed, appropriate, and allowable under jurisdiction WQS and federal NPDES requirements (USEPA 2004d).
- Watershed permits/trading—Watershed permits, which may accommodate nitrogen and phosphorus trading, may be used if such an approach would ensure protection of applicable

jurisdiction WQS and would be consistent with existing EPA policy regarding trading (USEPA 2004d).

In 2005 the seven Bay jurisdictions began implementing the new permitting approach. As of June 2010, the permits for the significant nitrogen and phosphorus sources have been issued with nitrogen and phosphorus limits consistent with the Tributary Strategy allocations (described in Section 1.2.1) (some of which may include compliance schedules) to 64 percent of the significant wastewater treatment facilities (305 out of the total 478), accounting for 74 percent of the total design flow, 76 percent of the total nitrogen loads and 91 percent of the total phosphorus loads from significant facilities (Table 4-6).

By the end of 2011, EPA expects all 478 significant wastewater treatment facilities in the Bay watershed to have annual nitrogen and phosphorus load limits in place in their permits (some of which may have compliance schedules as well).

Table 4-6. Nitrogen and phosphorus permit tracking summary under the Basinwide NPDES Wastewater Permitting Approach, through December 2010

Jurisdiction	Significant facility NPDES	Permits drafted	Permits issued	Design flow of facilities permits issued	Percent of design flow for permits issued/significant facilities
DC[a]	1	1	1	152.5	100%
DE	4	4	4	3.3	100%
MD	87	72	51	357.7	42%
NY	28	1	1	20.0	22%
PA	213	141	103	434.1	67%
VA	125	125	125	1,253.5	100%
WV[b]	20	16	16	27.737	100%
Total	478	364	305	2,259.7	74%

Source: USEPA Region 3, Region 2, Facilities identified in the final Phase 1 WIPs
Notes:
Some industrial design flows are not available or not comparable and not listed in the database. Some permits may contain compliance schedules.
a. Blue Plains WWTP serves DC and parts of MD and VA, but is only counted once.
b. Multiple facilities (4) share one NPDES permit in West Virginia.

4.5 REGULATED POINT SOURCE LOAD SUMMARIES

This section presents load estimates for each major point source sector.

4.5.1 Municipal Wastewater Discharging Facilities

A municipal wastewater facility is defined as a facility discharging treated wastewater from municipal or quasi-municipal sewer systems. EPA identified 3,582 NPDES permitted facilities as discharging municipal wastewater into the Chesapeake Bay watershed. Table 4-7 provides a summary of municipal wastewater facilities by jurisdiction; a complete list is available in Appendix Q.

Table 4-8 and Table 4-9 summarize modeled 2009 municipal wastewater loading estimates by jurisdiction and major river basin, respectively, for total nitrogen and phosphorus loads delivered to the Chesapeake Bay. Modeled sediment loads for those facilities are not presented because wastewater discharging facilities represent a *de minimis* source of sediment (i.e., less than 0.5 percent of the 2009 total sediment load). In 2009 municipal wastewater treatment facilities contributed an estimated 17 percent of the total nitrogen and 16 percent of the total phosphorus loads delivered to Chesapeake Bay.

Table 4-7. Municipal wastewater facilities by jurisdiction

Jurisdiction	Significant	Nonsignificant
DC	1	1
DE	3	1
MD	75	163
NY	26	26
PA	183	1246
VA	101	1618
WV	13	125
Total	402	3180

Source: EPA Region 3, EPA Region 2
Note: Blue Plains wastewater treatment plant serves DC and portions of Maryland and Virginia but is counted once in this table as a DC plant.

Table 4-8. Model estimated 2009 municipal wastewater loads by jurisdiction delivered to Chesapeake Bay

Jurisdiction	Flow (mgd)	Total nitrogen delivered (lb/yr)	Total phosphorus delivered (lb/yr)
DC	140	2,387,918	20,456
DE	2	42,529	4,984
MD	563	11,928,717	568,905
NY	62	1,360,684	159,096
PA	335	9,391,741	740,397
VA	585	16,926,806	1,047,998
WV	13	188,137	62,674
Total	1,698	42,226,535	2,604,509

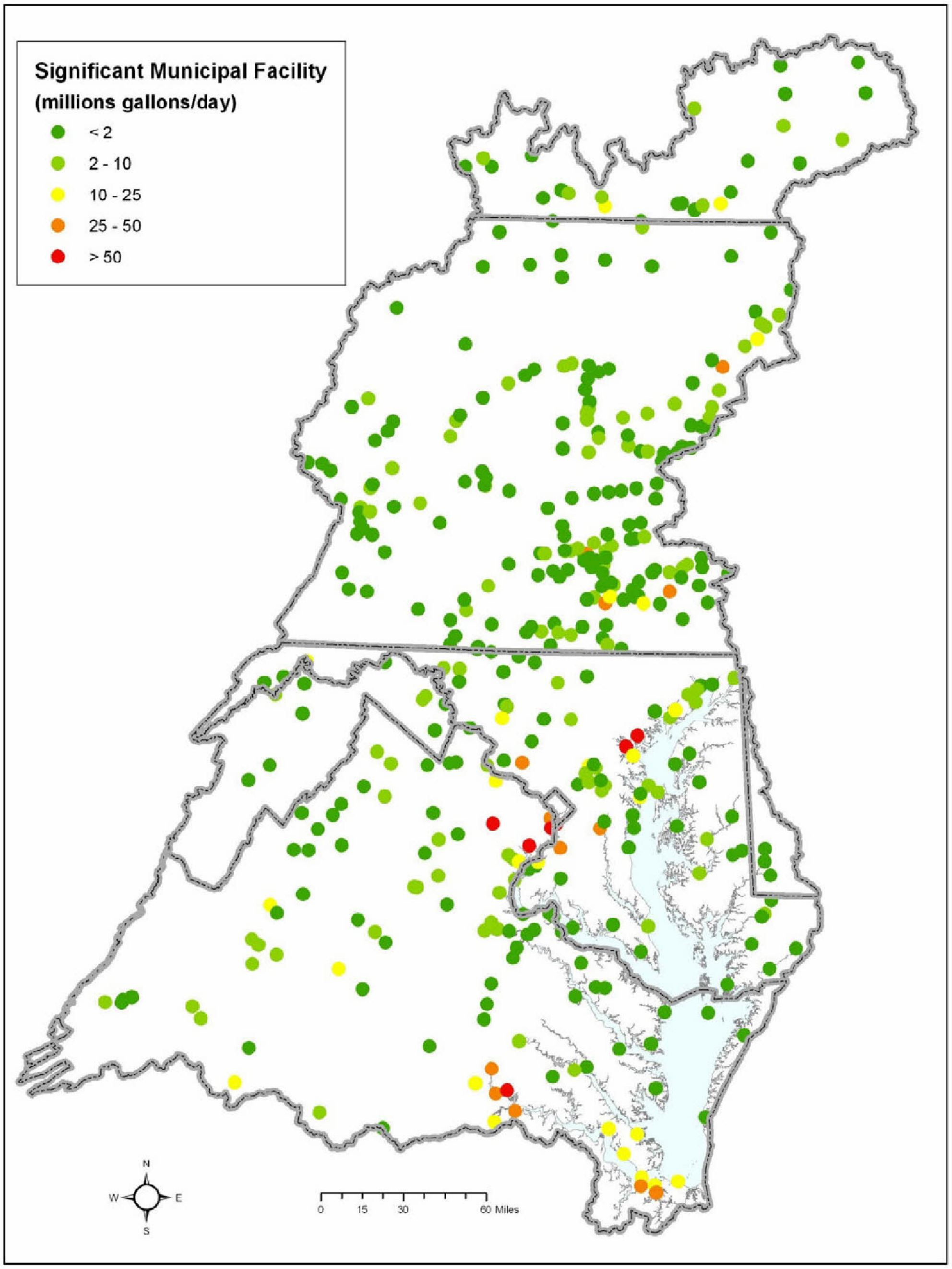
Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 4-9. Model estimated 2009 municipal wastewater loads by major river basin delivered to Chesapeake Bay

Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	383	10,556,831	835,426
MD Eastern Shore	25	696,872	70,540
MD Western Shore	254	7,279,406	331,362
Patuxent River	58	640,507	61,948
Potomac River	635	9,475,644	412,464
Rappahannock River	23	376,453	46,463
York River	20	691,550	45,012
James River	299	12,494,335	798,615
VA Eastern Shore	< 1	14,937	2,679
Total	1,698	42,226,535	2,604,509

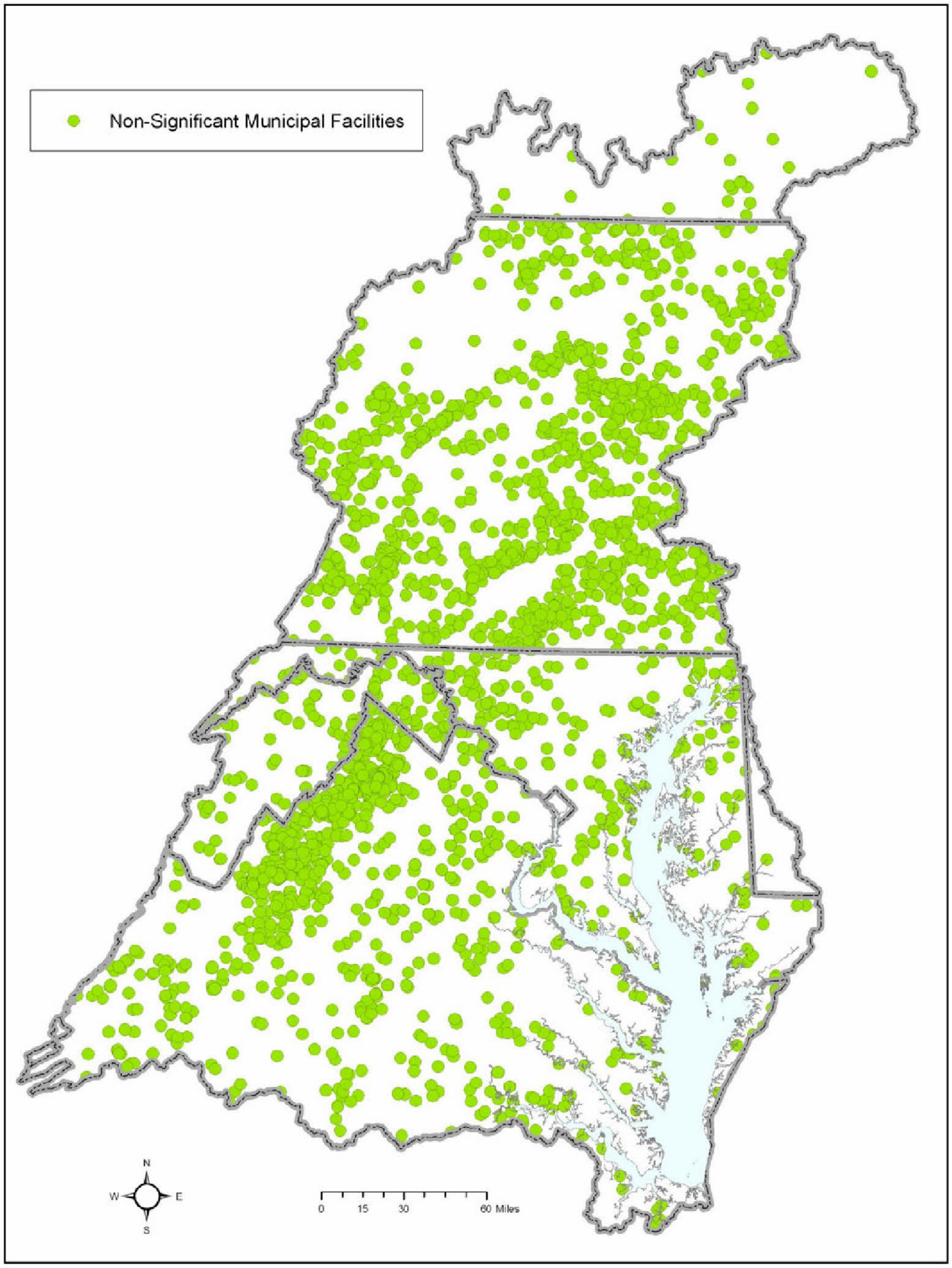
Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-7 and Figure 4-8 illustrate the prevalence and locations of significant and nonsignificant municipal wastewater discharge facilities, respectively, across the watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-7. Significant wastewater treatment facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-8. Nonsignificant municipal wastewater treatment facilities in the Chesapeake Bay watershed.

Data related to municipal and industrial facilities are in the Bay Watershed Model point source database maintained by the CBP and include information for the 478 significant industrial, municipal, and federal facilities discharging directly to the surface waters in the watershed. The wastewater data used to calibrate the Bay Watershed Model cover the 1984 to 2005 time frame and are updated annually as data become available. Data are largely supplied by the seven watershed jurisdictions but are also obtained from NPDES permit databases, including EPA's Permit Compliance System (PCS) and jurisdiction discharge monitoring reports (DMRs). For each facility outfall, the database includes monthly flow and monthly average concentrations for total nitrogen, ammonia, nitrate and nitrite, total organic nitrogen, total phosphorus, orthophosphate, total organic phosphorus, total suspended solids, biological oxygen demand, and DO.

Because the Bay jurisdictions are required to submit monthly concentration and flow data to EPA for only significant dischargers, the Bay Watershed Model point source database does not include comprehensive information useful for characterizing the nonsignificant facilities (especially nonsignificant industrials) for the Bay TMDL. For nonsignificant municipal facilities, all Bay jurisdictions conducted a one-time data collection in 2008 for the nitrogen and phosphorus discharge data, and estimates are based on any available data sources and default values recommended in *Chesapeake Bay Watershed Model Application and Calculation of Nutrient and Sediment Loadings – Appendix F: Phase IV Chesapeake Bay Watershed Model Point Source Load* (CBP 1998). EPA supplemented this information by querying the Integrated Compliance Information System database (ICIS) for jurisdictions that have migrated to ICIS as of 2009 (District of Columbia, Maryland, Pennsylvania, and New York), querying the PCS database for jurisdictions that have not yet migrated to ICIS (Delaware, Virginia and West Virginia), and obtaining Maryland and Virginia facility information directly from Maryland Department of the Environment (MDE) and Virginia Department of Environmental Quality (VADEQ), respectively.

For more information regarding the data used to represent municipal wastewater discharge facilities and how they were incorporated into modeling for the TMDL, see Section 7 of the Bay Watershed Model documentation at
http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

Appendix Q provides facility-specific information including NPDES ID, location, and more for all wastewater dischargers accounted for in the Bay TMDL.

4.5.2 Industrial Discharge Facilities

Industrial discharge facilities are facilities discharging process water, cooling water, and other contaminated waters from industrial or commercial sources. EPA identified 1,679 NPDES permitted facilities discharging industrial wastewaters in the Chesapeake Bay watershed (Table 4-10, Appendix Q), with 76 significant facilities (Figure 4-9) and 1,603 nonsignificant facilities (Figure 4-10). In 2009 industrial wastewater discharging facilities contributed an estimated 7.3 million pounds of the total nitrogen and 1.27 million pounds of the total phosphorus loads delivered to Chesapeake Bay (Table 4-11 and Table 4-12) an estimated 3 percent and 8 percent, respectively, of all nitrogen and phosphorus loads delivered to the Chesapeake Bay.

Table 4-12 summarizes modeled wastewater nitrogen and phosphorus loading estimates using 2009 loading conditions. Modeled sediment loads for industrial or commercial facilities are not presented because their wastewater discharges represent a *de minimis* source of sediment (i.e., less than 0.5 percent of the 2009 total sediment load).

Table 4-10. Industrial wastewater facilities

Jurisdiction	Significant	Nonsignificant
DC	0	9
DE	1	1
MD	12	477
NY	2	45
PA	30	409
VA	24	639
WV	7	23
Total	76	1,603

Source: USEPA Region 3, Region 2

Table 4-11. 2009 Load estimates of industrial facility discharges

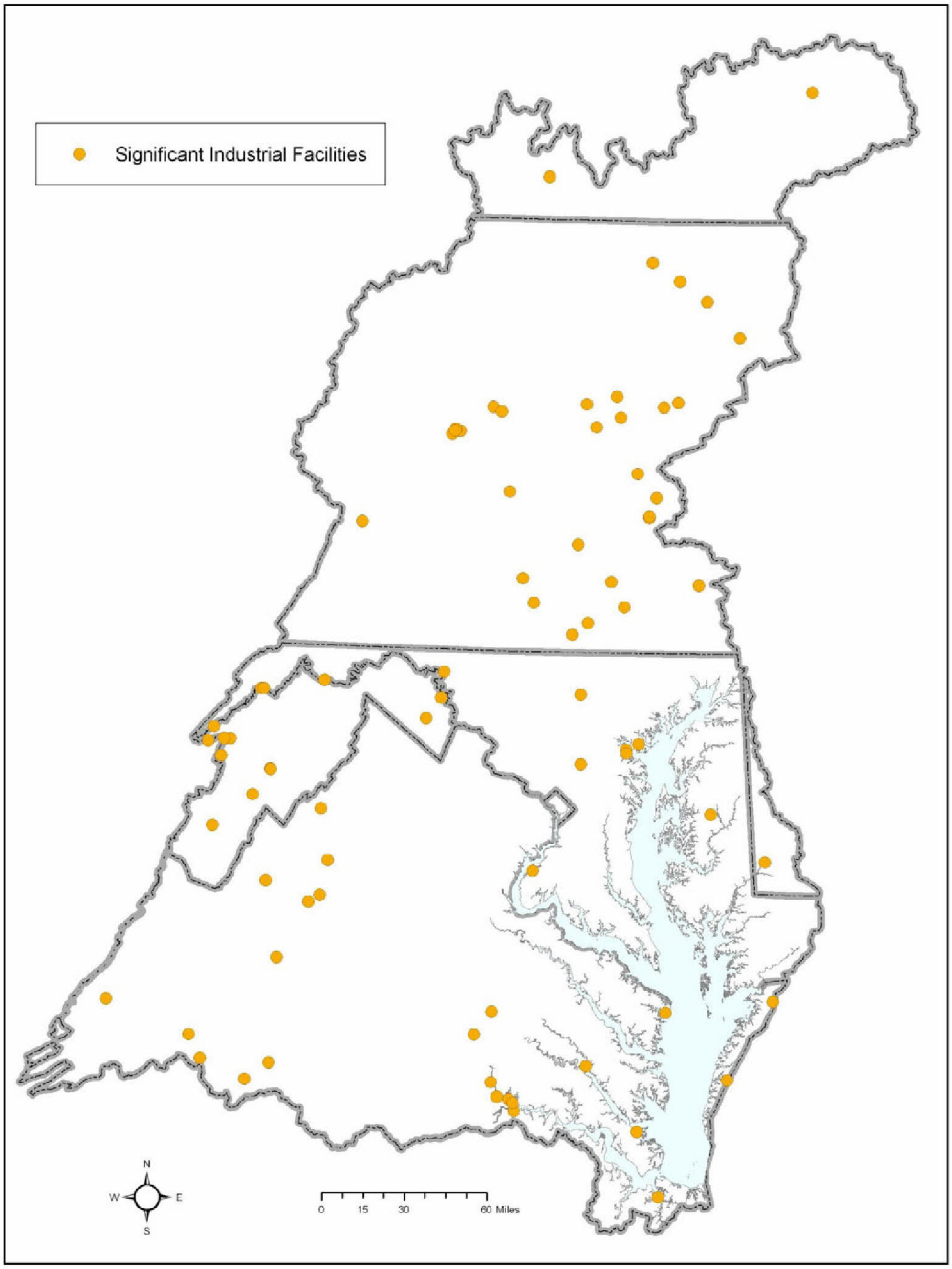
Jurisdiction	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
DC	13	183,490	20,433
DE	< 1	95,438	71
MD	48	1,989,243	267,093
NY	7	126,897	19,971
PA	179	2,010,639	260,140
VA	160	2,883,828	649,266
WV	14	55,213	53,592
Total	422	7,344,748	1,270,566

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Table 4-12. 2009 Flow, total nitrogen, and total phosphorus load estimates of industrial wastewater facility discharges by major river basin

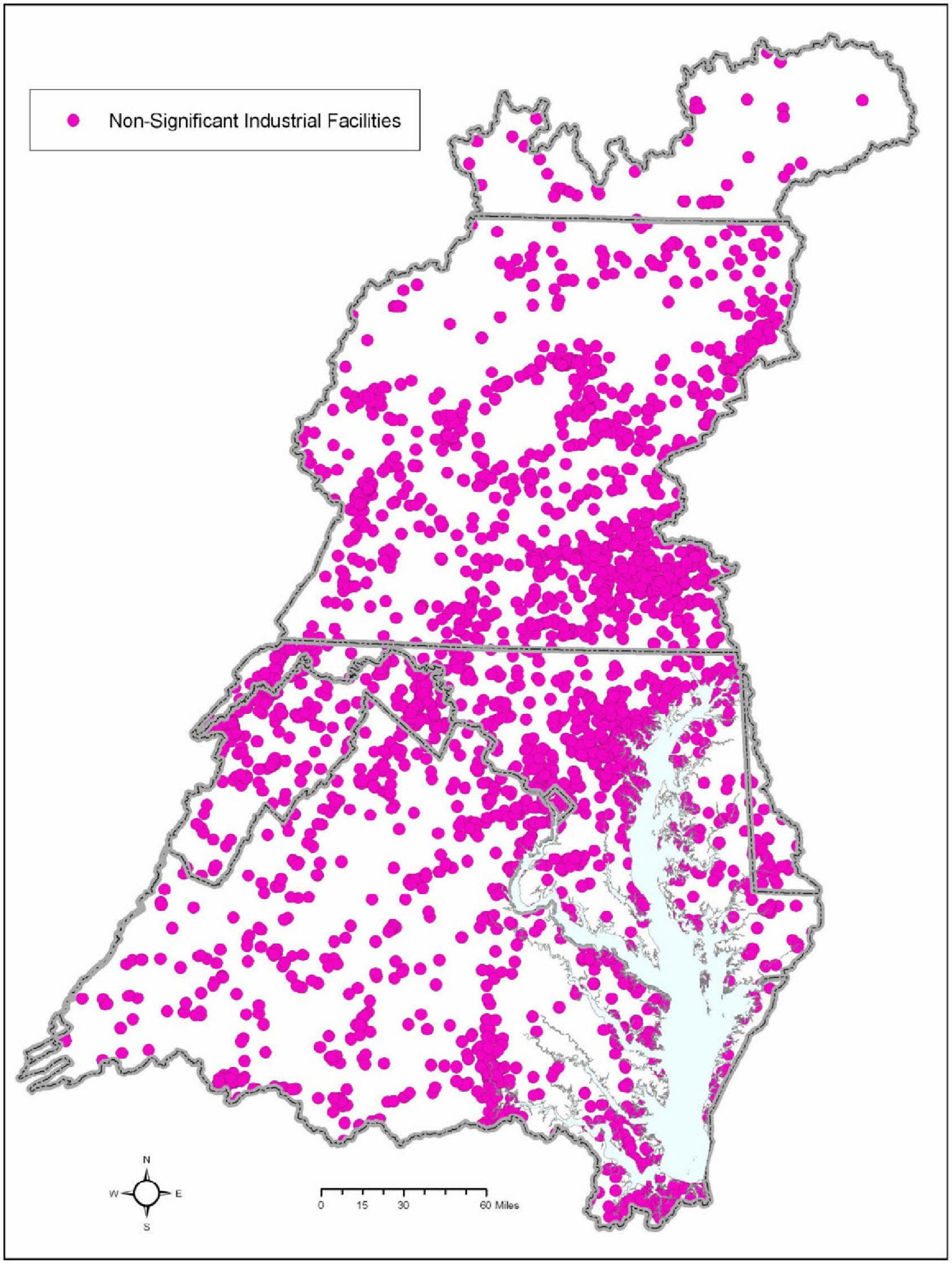
Basin	Flow (mgd)	Total nitrogen delivered (lbs/yr)	Total phosphorus delivered (lbs/yr)
Susquehanna River	184	2,171,197	281,922
MD Eastern Shore	5	302,210	45,626
MD Western Shore	21	1,369,383	105,100
Patuxent River	3	50,615	38,689
Potomac River	71	779,885	420,997
Rappahannock River	5	78,006	36,039
York River	81	478,892	81,675
James River	51	1,979,297	259,331
VA Eastern Shore	1	135,211	1,160
Total	422	7,344,697	1,270,539

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-9. Significant industrial wastewater discharge facilities in the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario.

Figure 4-10. Nonsignificant industrial wastewater discharge facilities in the Chesapeake Bay watershed.

Discharge Monitoring Report (DMR) data from the population of industrial facilities were used to derive loadings where available. The majority of nonsignificant industrial facilities do not have DMR data for nitrogen and phosphorus. However, the default values from typical pollutant concentrations (Tetra Tech 1999) were used to estimate the loads where DMR data are not available, except for power plants and other facilities with high flows.

Industrial facilities, such as power plants, petroleum refineries, and steel mills, that were not on the significant facility list were considered as high-flow, nonsignificant facilities in the evaluation. Nitrogen and phosphorus loads resulting from the use of flue gas desulfurization units, effluent from coal ash ponds and biocide applications at high-flow facilities were estimated from available databases. Data sets queried include EPA's PCS and ICIS permit systems, 316(b) cooling water intake structure regulation data, U.S. Department of Energy's Energy Information Administration data, and EPA's eGrid database.

Thirty-two power plants were identified as being in the Chesapeake Bay watershed. Eight of those facilities use cooling towers as part of their cooling system. Of the 32 facilities, 18 use coal as a fuel source; 7 use a flue gas desulfurization, and 13 use ash ponds. Eighty-nine other high-flow industrial sites were identified in the watershed and represent a variety of industrial activities.

Pollutant loads were estimated for the eight facilities that use cooling towers. The PCS and ICIS databases were queried for blowdown flows, and cooling tower chemical vendors were consulted to estimate water quality conditions in the towers. Facility use rates were then obtained from EPA's eGrid database to characterize utilization routines and variability in blowdown events. Similarly, flue gas desulfurization and ash pond loads were estimated using data obtained from the PCS and ICIS databases.

4.5.3 Combined Sewer Overflows

Combined sewer systems (CSS) are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. Normally, the systems transport wastewater to a treatment plant, where it is treated and discharged to surface waters. However, during heavy rainfall or snowmelt, flow volumes in a CSS can exceed the capacity of the sewer system or treatment plant. To avoid situations where excess flows overwhelm the sewer network or the treatment capacity of the treatment system, CSSs are designed to overflow during times of high volume, discharging untreated excess wastewater directly to nearby streams, rivers, or other waterbodies.

Such overflows, called combined sewer overflows (CSOs), contain stormwater and untreated human and industrial waste, toxic materials, and debris. There are 64 CSO communities in the Chesapeake Bay watershed (Table 4-13 and Figure 4-11).

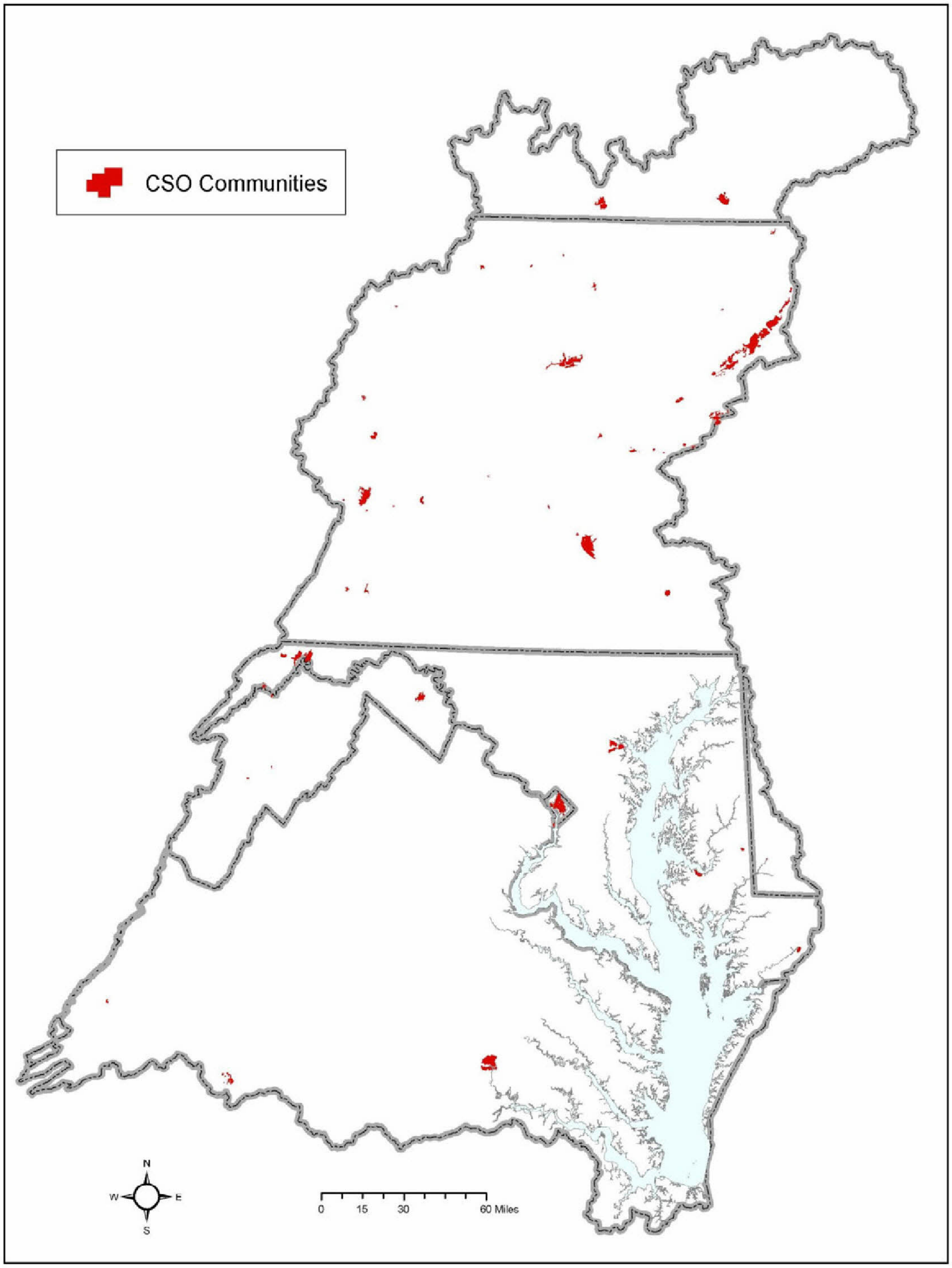
Table 4-13. Combined sewer system communities in the Bay watershed

Jurisdiction	River basin	NPDES ID	Facility name
DC	Potomac	DC0021199	Washington, District of Columbia
DE	Eastern Shore	DE0020265	Seaford Waste Treatment Plant
MD	Eastern Shore	MD0020249	Federalsburg WWTP
MD	Eastern Shore	MD0021571	City of Salisbury WWTP
MD	Potomac	MD0021598	Cumberland WWTP
MD	Patapsco	MD0021601	Patapsco WWTP
MD	Eastern Shore	MD0021636	Cambridge WWTP
MD	Eastern Shore	MD0022764	Snow Hill Water & Sewer Department
MD	Potomac	MD0067384	Westernport CSO
MD	Potomac	MD0067407	Allegany County CSO
MD	Potomac	MD0067423	Frostburg CSO
MD	Potomac	MD0067547	Lavale Sanitary Commission CSO
NY	Susquehanna	NY0023981	Johnson City (V) Overflows
NY	Susquehanna	NY0024406	Binghamton (C) CSO
NY	Susquehanna	NY0035742	Chemung Co Elmira SD STP
PA	Susquehanna	PA0020940	Tunkhannock Boro Municipal Authority
PA	Susquehanna	PA0021237	Newport Boro STP
PA	Susquehanna	PA0021539	Williamsburg Municipal Authority
PA	Susquehanna	PA0021571	Marysville Borough WWTP
PA	Susquehanna	PA0021687	Wellsboro WWTP
PA	Susquehanna	PA0021814	Mansfield Boro WWTP
PA	Susquehanna	PA0022209	Bedford WWTP
PA	Susquehanna	PA0023248	Berwick Area Joint Sewer Authority WWTP
PA	Susquehanna	PA0023558	Ashland WWTP
PA	Susquehanna	PA0023736	Tri-Boro Municipal Authority WWTP
PA	Susquehanna	PA0024341	Canton Boro Auth. WWTP
PA	Susquehanna	PA0024406	Mount Carmel WWTF
PA	Susquehanna	PA0026107	Wyoming Valley Sanitary Authority WWTP
PA	Susquehanna	PA0026191	Huntingdon Borough WWTP
PA	Susquehanna	PA0026310	Clearfield Mun. Auth. WWTP
PA	Susquehanna	PA0026361	Lower Lackawanna Valley Sanitary Authority WWTP
PA	Susquehanna	PA0026492	Scranton Sewer Authority WWTP
PA	Susquehanna	PA0026557	Sunbury City Municipal Authority WWTP
PA	Susquehanna	PA0026743	Lancaster City WWTP
PA	Susquehanna	PA0026921	Greater Hazelton Joint Sewer Authority WWTP
PA	Susquehanna	PA0027014	Altoona City Auth. - Easterly WWTP
PA	Susquehanna	PA0027022	Altoona City Auth. - Westerly WWTF
PA	Susquehanna	PA0027049	Williamsport Sanitary Authority – West Plant
PA	Susquehanna	PA0027057	Williamsport Sanitary Authority – Central Plant
PA	Susquehanna	PA0027065	LRBSA - Archbald WWTP
PA	Susquehanna	PA0027081	LRBSA - Clinton WWTP
PA	Susquehanna	PA0027090	LRBSA - Throop WWTP
PA	Susquehanna	PA0027197	Harrisburg Advanced WWTF
PA	Susquehanna	PA0027324	Shamokin Coal Twp Joint Sewer Authority
PA	Susquehanna	PA0028631	Mid-Cameron Authority

Jurisdiction	River basin	NPDES ID	Facility name
PA	Susquehanna	PA0028673	Gallitzin Borough Sewer and Disposal Authority
PA	Susquehanna	PA0036820	Galeton Borough Authority WWTP
PA	Susquehanna	PA0037711	Everett Area WWTP
PA	Susquehanna	PA0038920	Burnham Borough Authority WWTP
PA	Susquehanna	PA0043273	Hollidaysburg STP
PA	Susquehanna	PA0046159	Houtzdale Boro Municipal Sewer Authority
PA	Susquehanna	PA0070041	Mahanoy City Sewer Authority WTP
PA	Susquehanna	PA0070386	Shenandoah Municipal Sewer Authority WWTP
PA	Susquehanna	PAG062202	Lackawanna River Basin Sewer Authority.
PA	Susquehanna	PAG063501	Steelton Boro Authority
VA	James	VA0063177	Richmond
VA	James	VA0024970	Lynchburg
VA	James	VA0025542	Covington Sewage Treatment Plant
VA	Potomac	VA0087068	Alexandria
WV	Potomac	WV0020150	City of Moorefield
WV	Potomac	WV0021792	City of Petersburg
WV	Potomac	WV0023167	City of Martinsburg
WV	Potomac	WV0024392	City of Keyser
WV	Potomac	WV0105279	City of Piedmont

CSOs are considered point sources and are assigned WLAs in this TMDL. EPA's *CSO Control Policy* is the national framework for implementing controls on CSOs through the NPDES permitting program. The policy resulted from negotiations among EPA, municipal organizations, environmental groups, and state agencies. It provides guidance to municipalities and state and federal permitting authorities on how to meet the CWA's pollution control goals as flexibly and cost-effectively as possible. The CSO policy was published in the *Federal Register* (FR) (59 FR 18688, April 19, 1994). CSO communities are required to develop Long-Term Control Plans (LTCPs), detailing steps necessary to achieve full compliance with the CWA.

EPA relied on various sources of information to characterize the prevalence of CSOs in the Bay watershed and to quantify their loads for the Bay TMDL. There are 64 CSO communities in the Bay watershed (Table 4-13). Overflow volume and pollutant loading from CSO communities are heavily dependent on the service area or catchment area of the combined system. Service area data obtained from the communities were used to calculate the loading from each community during high-flow events. Precipitation data observations were also obtained from weather monitoring stations proximate to each community to derive runoff volumes. Estimates of overflows and associated pollutant loads from CSO communities were then developed using various sources of water quality data including monitoring data and literature values.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-11. CSO communities in the Chesapeake Bay watershed.

For four of the largest CSO communities in the watershed—Alexandria, Virginia; Lynchburg, Virginia; Richmond, Virginia; and the District of Columbia—EPA relied heavily on readily available and relatively detailed LTCPs to characterize overflows. In addition, EPA ran simulations of existing sewer models for those communities to support developing overflow and water quality estimates. EPA used the District of Columbia's CSS model to develop loading estimates for the CSOs. For the Alexandria, Richmond, and Lynchburg CSSs, various versions of EPA's Storm Water Management Model (SWMM) were used to estimate overflows. CSO discharge monitoring data were available for the Alexandria and Richmond CSSs, but no samples were available from Lynchburg because the LTCP calls for complete separation of this system (i.e., separation of the storm sewers from sanitary sewers).

Information related to loading from the other 60 CSO communities in the watershed includes spatial data collected as a result of a direct survey of the communities to support the TMDL, limited water quality and overflow data from some of the CSO communities in the watershed, and representative water quality concentrations available in the literature. For further information regarding the data used to estimated CSO loads, see Section 7 of the Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

To avoid the difficulty of measuring LTCP implementation progress with weather-dominated CSO loading estimates, EPA used the 10-year average CSO loads for 1991–2000, which correlates with the hydrologic period selected for the TMDL (see Section 6.1.1). The loads from that 10-year period were used as the baseline to assess CSO progress and WLAs. Any CSO implementation progress will be tracked and input in the model as a reduction factor to represent a reduction achieved from the baseline. Thus, any reduction will be from management actions only and not from climate variation. The CSS land use will be changed to urban area for stormwater simulation in the model if there is CSS separation in the implementation plan and the separation acreage is reported with the reduction factor for implementation progress tracking.

4.5.4 Sanitary Sewer Overflows

Properly designed, operated, and maintained sanitary sewer systems are meant to collect and transport all the sewage that flows into them to a WWTP. SSOs are illegal discharges of raw sewage from municipal sanitary sewer systems. Frequent SSOs are indicative of problems with a community's collection system and can be due to multiple factors:

- Infiltration and inflow contributes to SSOs when rainfall or snowmelt infiltrates through the ground into leaky sanitary sewers or when excess water flows in through roof drains connected to sewers, broken pipes, or badly connected sewer service lines. Poor service connections between sewer lines and building service lines can contribute as much as 60 percent of SSOs in some areas.
- Undersized systems contribute to SSOs when sewers and pumps are too small to carry sewage from newly developed subdivisions or commercial areas.
- Pipe failures contribute to SSOs as a result of blocked, broken, or cracked pipes; tree roots growing into the sewer; sections of pipe settling or shifting so that pipe joints no longer match; and sediment and other material building up causing pipes to break or collapse.
- Equipment failures contribute to SSOs because of pump failures or power failures.

SSOs represent a source of nitrogen and phosphorus to the Chesapeake Bay; however, information available to characterize their contribution to the overall nitrogen and phosphorus loads delivered to the Bay is limited largely because of their illegality and infrequency. Although the Bay Watershed Model does not specifically account for SSOs, the nitrogen and phosphorus load contributions from SSOs are part of the background conditions incorporated into the Phase 5.3 watershed model and, therefore, such loads are accounted for in the data used for calibration of the Bay Watershed Model. Because SSOs are illegal, however, the Chesapeake Bay TMDL assumes full removal of SSOs and makes no allocation to them.

4.5.5 NPDES Permitted Stormwater

Urban and suburban stormwater discharges contain nitrogen, phosphorus, and sediment from sources such as pet wastes, lawn fertilizers, construction activity, impervious surfaces, and air contaminants. The in-stream bank and bed scouring caused by increased volumes and durations of stormwater discharges contribute additional sediment and nitrogen and phosphorus loads to the Bay and its tributaries. Those nitrogen, phosphorus, and sediment loads affect local water quality, habitats, and the Bay downstream and represent a significant proportion of nitrogen, phosphorus, and sediment loads to Bay. The CBP estimates that in 2009 stormwater from urban and suburban development contributed to 16 percent of the sediment loadings, 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (Bay Watershed Model 2009 Scenario).

Under the federal stormwater regulatory program, three broad categories of stormwater discharges are regulated (see 40 CFR 122.26, CFR 122.30-37):

- Stormwater discharges from medium and large Municipal Separate Storm Sewer Systems (MS4s) and small MS4s in Census Bureau defined urbanized areas
- Stormwater discharges associated with construction activity 1 acre and larger
- Stormwater discharges associated with specified categories of industrial activity

In addition, EPA established a process for designating and requiring NPDES permit coverage for additional stormwater discharges, implementing section 402(p)(2)(E). This *residual designation authority* (RDA) of section 402(p)(2)(E) is in 40 CFR 122.26(a)(9)(i)(C) and (D). EPA retains additional authority in CWA section 402(p)(5) and (6) to designate additional point sources of stormwater.

EPA's intent in creating the MS4 Stormwater Program was to regulate stormwater discharges by requiring the municipalities to develop management programs to control stormwater discharging via the MS4, i.e., stormwater collected by the MS4 from throughout its service area.

CWA section 402(p) establishes the framework for EPA to address stormwater discharges. In Phase I, EPA established NPDES permit requirements for stormwater discharges associated with

- Industrial activity, including construction activity disturbing 5 acres or greater, including sites smaller than 5 acres if they are associated with a common plan of development or sale that is at least 5 acres in size
- Discharges from MS4s serving populations of 100,000 or more

In Phase II, EPA established permit requirements for stormwater discharges from

- Construction activity disturbing 1 to 5 acres, including sites smaller than 1 acre if they are associated with a common plan of development or sale that is at least 1 acre in size
- Small MS4s serving populations of fewer than 100,000 in urbanized areas

With respect to Phase II MS4s, EPA considers stormwater discharges from within the geographic boundary of the urbanized area (and designated areas) served by small MS4s to be regulated (64 FR 68722, 68751-52 and 68804, Appendix 2, December 8, 1999). The reason for regulating small MS4s in urbanized areas was based on the correlation between the degree of development/ urbanization and adverse water quality impacts from stormwater discharged from such areas.

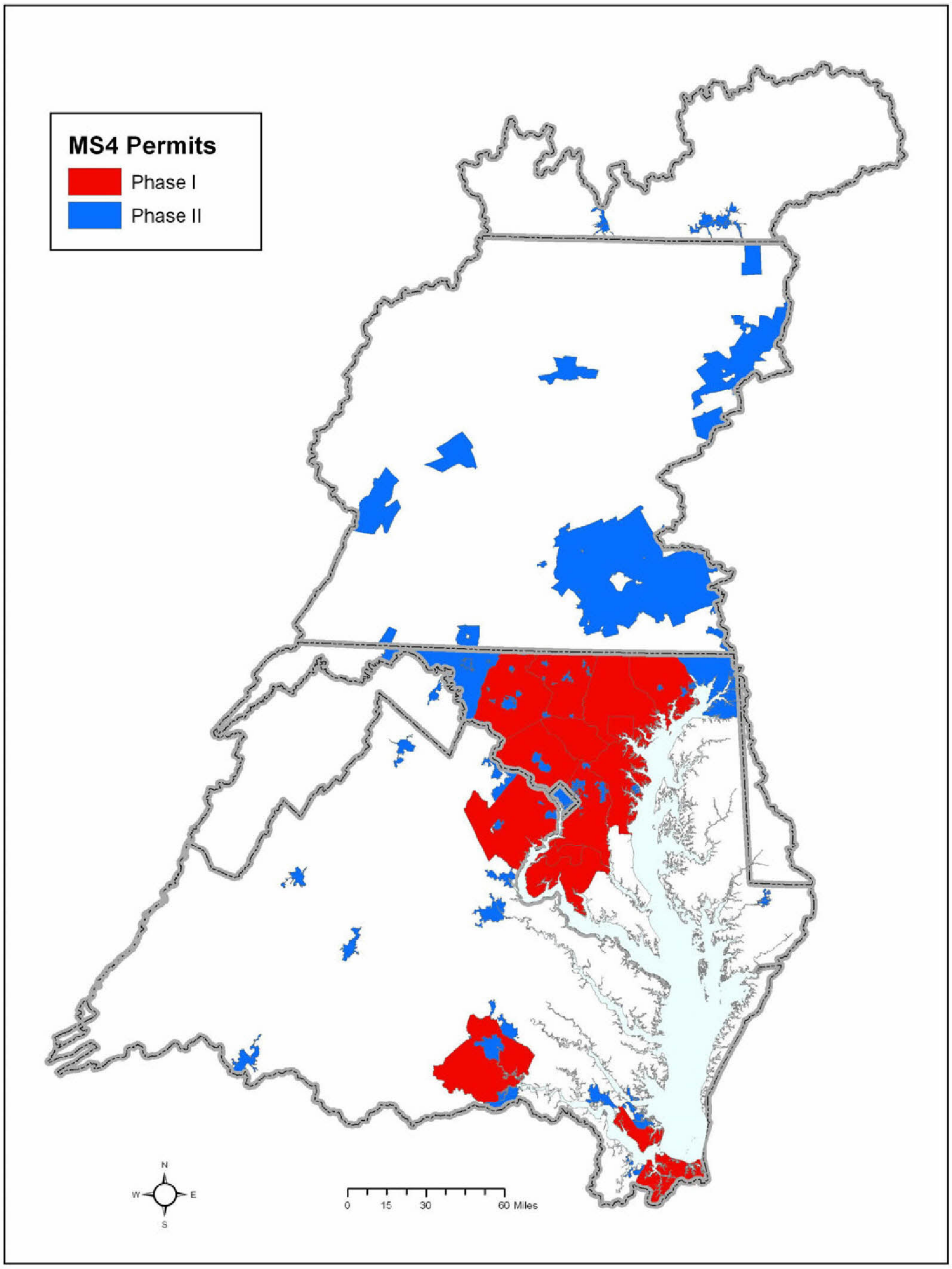
EPA can and has designated additional stormwater discharges, such as those from impervious surfaces above a certain size threshold, using its residual designation authority under 40 CFR 122.26(a)(9)(i)(C) and (D). At the discretion of the NPDES permitting authority, stormwater dischargers that require NPDES permits can either obtain individual permits or, with the exception of medium and large MS4s, obtain coverage under general permits (see 40 CFR 122.28). Also, EPA has additional authority in CWA section 402(p)(5) and (6) to designate additional point sources of stormwater.

Figure 4-12 shows the locations of Phase I and II MS4s in the Bay watershed.

Unless stormwater discharges are identified in EPA's Phase I or Phase II regulations or are designated pursuant to CWA section 402(p)(2)(E) or 402(p)(6), the discharges are not regulated under CWA section 402. As explained in EPA guidance, "stormwater discharges that are regulated under Phase I or Phase II of the NPDES stormwater program are point sources that must be included in the WLA portion of a TMDL" (USEPA 2002). Appendix Q includes the stormwater permits subject to this Bay TMDL.

It is estimated that existing NPDES MS4 areas contributed approximately 7,027,362 lbs total nitrogen, 900,868 lbs total phosphorus, and 287,295 tons of sediment annually in 2009. That compares to the total load delivered annually to the Bay of 251,040,081 lbs total nitrogen, 16,619,332 lbs total phosphorus and 4,000,118 tons sediment by all sources (Bay Watershed Model 2009 Scenario).

The contribution from industrial stormwater discharges subject to NPDES permits has been estimated on the basis of data submitted by jurisdictions in their Phase I WIPs, including the number of industrial stormwater permits per county and the number of urban acres regulated by industrial stormwater permits. For the Bay TMDL, the permitted industrial stormwater load is subtracted from the MS4 load when applicable. Table 4-14 provides an accounting of the current individual and general stormwater NPDES permits issued within the Chesapeake Bay watershed.



Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario

Figure 4-12. Phase I and II MS4s in the Chesapeake Bay watershed.

Table 4-14. NPDES stormwater permittees by jurisdiction and in the Chesapeake Bay watershed, summer 2009

Jurisdiction		NPDES Stormwater permit type: MS4 Phase I	MS4 Phase II	Industrial	Construction	Total	% Permittees in the Bay
DC	Baywide	1	0	60	212	273	1.6%
	Districtwide	1	0	60	212	273	
DE	Baywide	1	0	48	NA*	49	0.3%
	Statewide	14	3	337	1,375	1,729	
MD	Baywide	11	82	1,578	8,300	9,971	57.6%
	Statewide	11	82	1,578	8,332	10,003	
NY	Baywide	0	34	122	470	626	3.6%
	Statewide	1	502	1,393	7,251	9,147	
PA	Baywide	0	206	1,238	906	2,350	13.6%
	Statewide	2	727	2,494	2,399	5,622	
VA	Baywide	11	75	975	2,252	3,313	19.2%
	Statewide	11	90	1,432	2,851	4,384	
WV	Baywide	0	3	113	651	767	4.4%
	Statewide	0	45	933	2,488	3,466	
Total	Bay	23	400	4,086	12,791	17,300	100%
	States	40	1,449	8,227	24,908	34,624	

Source: Phase 5.3 Chesapeake Bay Watershed Model 2009 Scenario
Note: Numbers of permittees are not static, and especially for categories like construction are fluctuating regularly.
* Not including Delaware

Data used to characterize loads from regulated stormwater activities and to represent these sources in the model are available from the jurisdictions' NPDES programs and from EPA Region 3's NPDES permitting, the permitting authority in the District of Columbia and for federal facilities in Delaware. Details related to how loads for MS4s and NPDES-permitted construction and industrial stormwater activities were derived for the Bay TMDL are in Section 7 of the Phase 5 Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.5.6 Concentrated Animal Feeding Operations

The NPDES program regulates the discharge of pollutants from point sources to waters of the United States. Concentrated Animal Feeding Operations (CAFOs) are included in the definition of point sources in CWA section 502(14). To be considered a CAFO, a facility must first be defined as an AFO.

AFOs are agricultural operations where animals are kept and raised in confined situations. AFOs generally congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. Such operations are defined as AFOs if animals are confined for 45 or more days per year in facilities where vegetation and other growth are not present during the normal growing season [40 CFR 122.42(b)(1)].

AFOs that meet the regulatory definition of a CAFO or that are designated as a CAFO are regulated under the NPDES permitting program and are required to seek NPDES permit coverage if they discharge or propose to discharge. The NPDES regulations define AFOs as CAFOs based primarily on the number of animals confined (Table 4-15) (for example, a large dairy CAFO confines 700 or more dairy cattle) [40 CFR 122.23(b)(2), (4), and (6)]. An AFO that is not defined as a CAFO may be designated as a CAFO if it meets certain conditions [40 CFR 122.23(c)].

Table 4-15. Federal numeric thresholds for small, medium, and large CAFOs

Animal sector	Size thresholds (number of animals)		
	Large CAFOs	**Medium CAFOs**	**Small CAFOs**
Cattle or cow/calf pairs	1,000 or more	300–999	less than 300
Mature dairy cattle	700 or more	200–699	less than 200
Veal calves	1,000 or more	300–999	less than 300
Swine (weighing over 55 pounds)	2,500 or more	750–2,499	less than 750
Swine (weighing less than 55 pounds)	10,000 or more	3,000–9,999	less than 3,000
Horses	500 or more	150–499	less than 150
Sheep or lambs	10,000 or more	3,000–9,999	less than 3,000
Turkeys	55,000 or more	16,500–54,999	less than 16,500
Laying hens or broilers (liquid manure handling systems)	30,000 or more	9,000–29,999	less than 9,000
Chickens other than laying hens (other than a liquid manure handling systems)	125,000 or more	37,500–124,999	less than 37,500
Laying hens (other than a liquid manure handling systems)	82,000 or more	25,000–81,999	less than 25,000
Ducks (other than a liquid manure handling systems)	30,000 or more	10,000–29,999	less than 10,000
Ducks (liquid manure handling systems)	5,000 or more	1,500–4,999	less than 1,500

Source: 40 CFR 122.23(b)

Under federal regulations, NPDES permits for CAFOs require CAFOs to implement the terms of a site-specific nutrient management plan (NMP) that includes a number of critical minimum elements [40 CFR 122.42(e)(1)]. Those requirements limit nitrogen and phosphorus loads from the production area as well as from the land application area, where manure, litter and process wastewater must be applied in accordance with site-specific practices to ensure that nitrogen and phosphorus in the manure will be used appropriately. NPDES permits for all CAFOs must include technology-based effluent limits in accordance with 40 CFR 122.44. Permitted Large CAFOs that land-apply manure, litter or process wastewater must comply with technology-based effluent limitations for land application per the effluent limitations guidelines (ELGs) at 40 CFR 412 (C) and (D). Unpermitted Large CAFOs may not have any discharges except for agricultural stormwater discharges from the land application area.

Agricultural stormwater discharges are the precipitation-related discharges from CAFO land application areas where the CAFO land applies manure, litter or process wastewater in accordance with nutrient management practices "that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater" applied to the land—i.e., for permitted CAFOs, the terms of an NMP concerning land application [40 CFR 122.23(e)(1)]. State technical standards are used in calculating the technology-based effluent limits in NPDES permits of Large CAFOs. Requirements for land application areas at small and medium CAFOs are based on the best professional judgment of the permit writer, and may also incorporate state technical standards. The agricultural stormwater exemption does not apply to a CAFO's production area. As a nonpoint source, an agricultural stormwater discharge is not subject to NPDES permitting requirements or water quality-based effluent limitations (WQBELs).

Any permit issued to a CAFO of any size must include a requirement to implement an NMP that contains, at a minimum, BMPs that meet the requirements specified in 40 CFR 122.42(e)(1). These include the following:

- Ensuring adequate storage of manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facility.
- Managing mortalities to ensure that they are not disposed of in a liquid manure, stormwater, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities.
- Ensuring that clean water is diverted, as appropriate, from the production area.
- Preventing direct contact of confined animals with waters of the United States.
- Ensuring that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or stormwater storage or treatment system unless specifically designed to treat such chemicals and other contaminants.
- Identifying appropriate site-specific conservation practices to control runoff of pollutants to waters of the United States.
- Identifying protocols for appropriate testing of manure, litter, process wastewater, and soil.
- Establishing protocols to land apply manure, litter, or process wastewater in accordance with site-specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater.
- Identifying specific records that will be maintained to document the implementation and management of the minimum elements described above.

EPA and the jurisdictions have estimated the number of state or federal permitted CAFOs in the Chesapeake Bay watershed, in part, on the basis of the jurisdictions' respective final Phase I WIPs (Table 4-16).

Table 4-16. Estimated number of state or federal permitted CAFOs

Jurisdiction	# State or federal permitted CAFOs
Delaware[a]	165
Maryland[a]	365
New York	65
Pennsylvania	325
Virginia	30
West Virginia	30
Total	980

Sources: State data submitted to EPA for the Senate Environment and Public Works Committee Hearing on the Chesapeake Bay on April 20, 2009, and EPA Office of Wastewater Management's latest NPDES CAFO Rule Implementation Status quarterly national CAFO number update. http://www.epa.gov/npdes/pubs/tracksum1Q10.pdf.
Note:
a. The numbers of CAFOs in Maryland and Delaware with permits are estimated according to the number of Notices of Intent (NOIs) received as a result of the EPA February 2009 permit application deadline. The NOIs are being reviewed for permit requirement completeness.

4.6 NONPOINT SOURCES

The term *nonpoint source* means any source of water pollution that does not meet the legal definition of point source (see Section 4.5). Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. For purposes of the Chesapeake Bay TMDL analysis and modeling, nonpoint sources in the Chesapeake Bay watershed have been evaluated under the following categories:

- Agriculture (manure, biosolids, chemical fertilizer)
- Atmospheric deposition
- Forest lands
- On-site wastewater treatment systems (OSWTSs)
- Nonregulated stormwater runoff
- Oceanic inputs
- Streambank and tidal shoreline erosion
- Tidal resuspension
- Wildlife

For the Bay TMDL, Scenario Builder was used to provide the land use-based scenario inputs to the Bay Watershed Model including forest lands, OSWTSs , nonregulated stormwater runoff, oceanic inputs, streambank and tidal shoreline erosion, tidal resuspension, and wildlife (see Section 5.7). Data sources for agriculture and atmospheric deposition in the Chesapeake Bay watershed are included in the relevant sections below. Scenario Builder provides estimates of nitrogen and phosphorus loads to the land and the area of soil available to be eroded. Loads are input to the Bay Watershed Model to generate modeled estimates of loads delivered to the Bay. Additional information related to Scenario Builder and its application in Bay TMDL development (USEPA 2010d) is at http://archive.chesapeakebay.net/pubs/SB_V22_Final_12_31_2010.pdf.

4.6.1 Agriculture

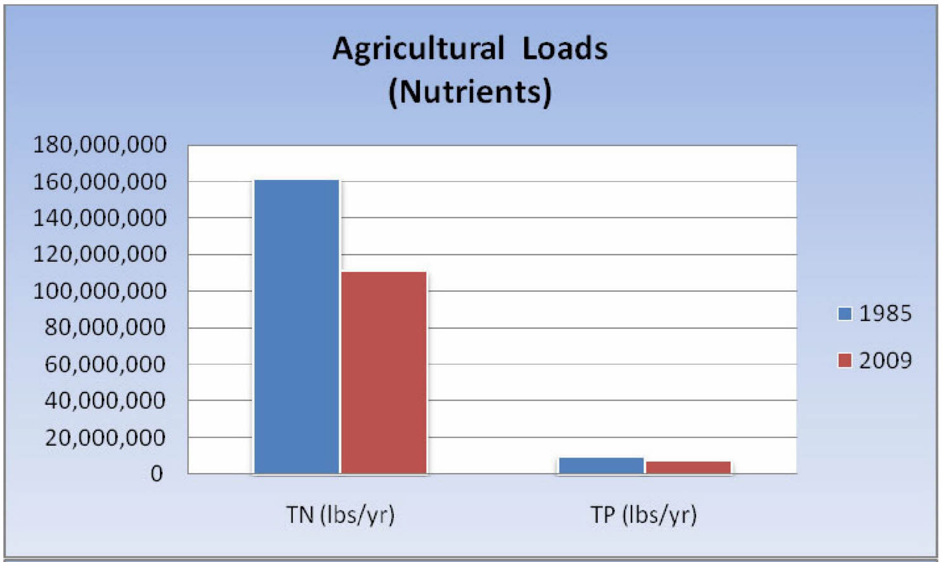
Agricultural lands account for 22 percent of the watershed, making agriculture one of the largest land uses in the area, second only to forested and open wooded areas (69 percent). The Bay watershed has more than 87,000 farm operations and 6.5 million acres of cropland. However, the District of Columbia does not include any agricultural lands.

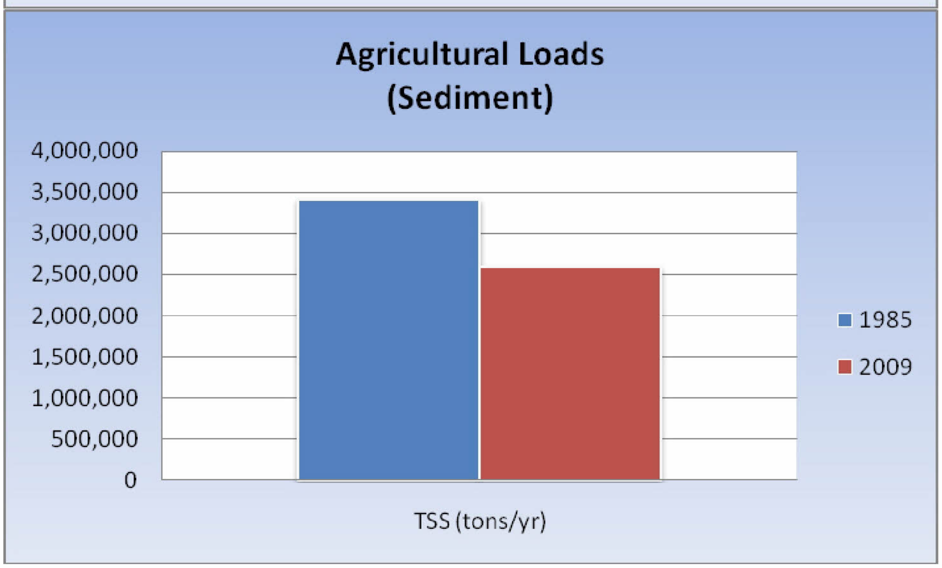
Farms in the Chesapeake Bay watershed produce more than 50 named commodities. The area's primary crops are pasture, hay, corn, wheat, soybeans, vegetables, and fruits. The eastern part of the region is home to a rapidly expanding nursery and greenhouse industry.

Animal operations account for more than 60 percent of the region's annual farm product sales. In the watershed, the six major types of animal operations are dairy cows, beef cattle, pigs, egg production, broilers, and turkeys. The three major animal production regions in the watershed, according to livestock concentration, are the lower Susquehanna River in Pennsylvania, the Shenandoah Valley in Virginia and West Virginia, and the Delmarva Peninsula in Delaware, Maryland, and Virginia. The Delmarva Peninsula is considered to be one of the country's top poultry producing regions and, according to the 2002 Census, three Bay counties are among the top 20 poultry producing counties in the nation (for either poultry/eggs, broilers, or layers): Sussex County, Delaware; Lancaster County, Pennsylvania; and Wicomico County, Maryland. In addition, at least one Bay county is among the top 20 counties for production of the following farm commodities: turkeys; cattle and calves; milk and other cow dairy products; hogs and pigs; horses and ponies; corn for silage; snap beans; apples; short rotation woody crops; and nursery, greenhouse, floriculture, and sod.

Agriculture is the largest single source of nitrogen, phosphorus, and sediment loading to the Bay through applying fertilizers, tilling croplands, and applying animal manure. Agricultural activities are responsible for approximately 44 percent of nitrogen and phosphorus loads delivered to the Bay and about 65 percent of sediment loads delivered to the Bay (Bay Watershed Model 2009 Scenario). Figure 4-13 compares modeled loads from agricultural lands for 1985 and 2009.

Data sources used to estimate nitrogen, phosphorus, and sediment from agriculture-related sources include information related to livestock production and manure generation, crop production and nutrient management, fertilizer use and application, and implementation of BMPs. EPA in cooperation with the Chesapeake Bay Program's Agricultural Nutrient and Sediment Reduction Workgroup and Modeling Subcommittee relied on the many sources of information to characterize loads related to agriculture that are summarized in Section 2 of the Scenario Builder documentation *Estimates of County-Level Nitrogen and Phosphorus Data for Use in Modeling Pollutant Reduction*(USEPA 2010d). Examples of data sources are the U.S. Department of Agriculture (USDA) Agricultural Census; USDA, state, and university nutrient management standards and handbooks; peer-reviewed journal articles; agricultural conservation data from state agricultural and environmental agencies; county agencies, and nongovernmental organizations; and extensive input from members of the Chesapeake Bay Program's Agricultural Nutrient and Sediment Reduction Workgroup.





Source: Phase 5.3 Chesapeake Bay Watershed Model 1985 and 2009 Scenarios

Figure 4-13. 1985 and 2009 modeled total nitrogen, phosphorus, and sediment loads from agricultural lands across the Chesapeake Bay watershed.

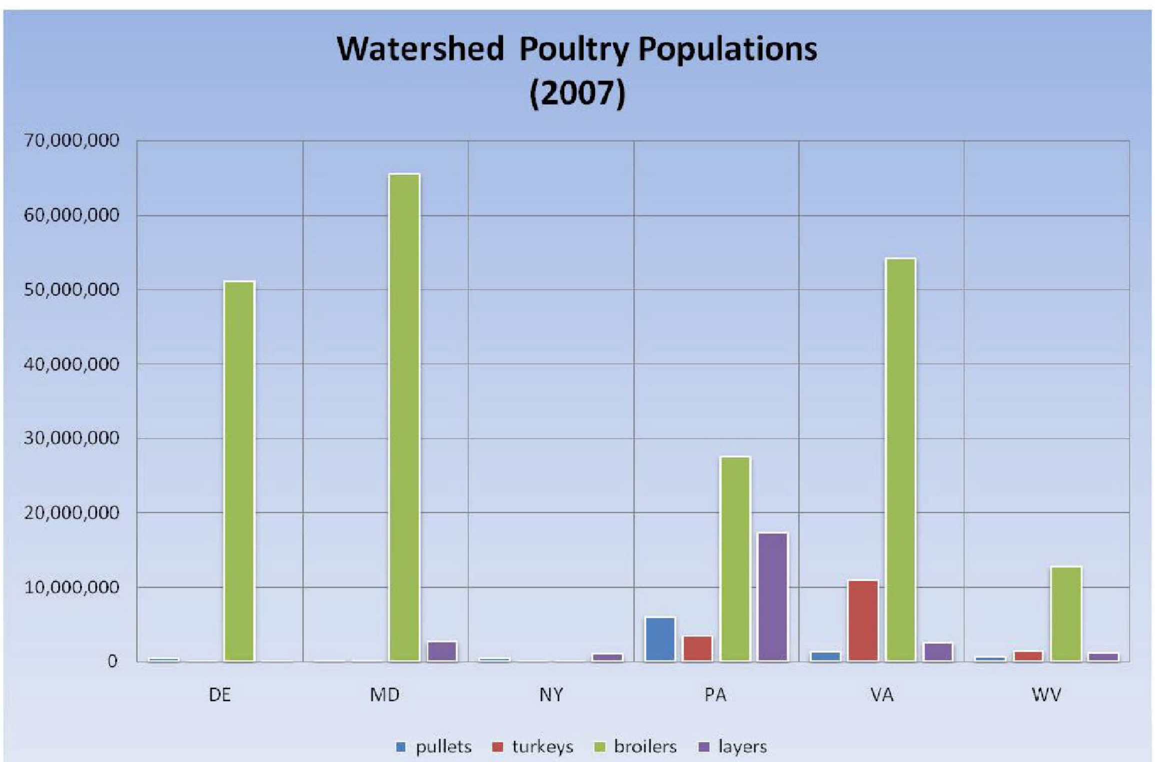
Manure

Animal populations vary across the Bay watershed by animal type and management. Pastures exist in the watershed for dairy and beef heifers, goats, hogs, and in some places even chickens and turkeys. Animal feed BMPs are recognized by the Chesapeake Bay watershed model, and managing manure from production areas can include a suite of BMPs for storage and handling. Land application of manure is an important nitrogen and phosphorus recycling process in agriculture. Because manure is so extensively used as a resource of nitrogen and phosphorus, it is considered as important as inorganic fertilizer and is an important source of nonpoint source pollution. Figure 4-14 and Figure 4-15 provide historical population data of poultry and non-poultry animals in the watershed, respectively.

Annual manure production is calculated as a daily excreted amount per animal equivalent unit (1 animal equivalent unit equals 1,000 lbs live animal weight). Animal units are estimated for counties on the basis of USDA Agricultural Census data. The total amount of manure produced is then distributed among the applicable land uses, which include pasture, AFO, and other row crop land uses. The percentage of time animals spend in pasture (based on state recommendations) is used to estimate the percentage of total manure produced on pasture lands. For example, 50 percent pasture time equates to 50 percent of the total manure production occurring on pasture lands. Manure produced that is associated with time spent confined is considered to be generated on AFO acres. A fraction of that amount, (15–21 percent depending on animal type) is assumed to remain on the AFO acres (i.e., not captured by storage and handling activities), while the rest is redistributed by land application to pasture and row crop lands. The model simulates AFO acres similarly to urban impervious areas.

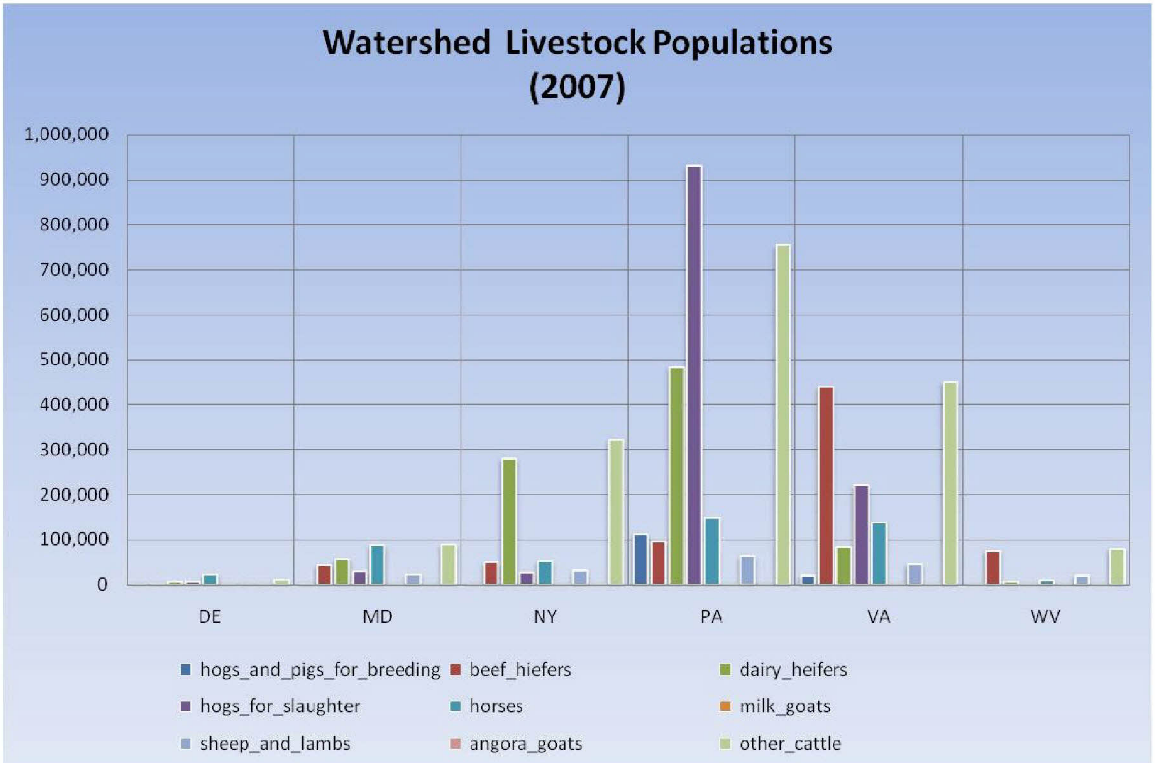
Biosolids

Applying biosolids, the nutrient-rich organic materials resulting from treating sewage sludge, as fertilizer to croplands represents another source of nutrients to the Bay. Biosolids typically contain plant nutrients (nitrogen, phosphorus, and potassium), although the amount of nutrients available from biosolids are normally lower than the amounts from most commercial fertilizers (Huddleston and Ronayne 1990). Nitrogen and phosphorus are the most prevalent nutrients found in sewage sludge.



Source: 2007 Agriculture Census

Figure 4-14. 2007 Chesapeake Bay watershed poultry populations by jurisdiction.



Source: 2007 Agriculture Census

Figure 4-15. 2007 Chesapeake Bay watershed livestock populations by jurisdiction.

Regulations governing use, disposal and application of sewage sludge are in EPA's Sewage Sludge Use or Disposal Regulation (Part 503), which provides a framework for permitting sewage sludge use or disposal. No jurisdictions in EPA Region 3 have applied for program authorization of the federal Part 503. Although all Bay jurisdictions have their own sewage sludge programs in place, only Virginia routinely submits to EPA information regarding land application of biosolids. As a result, information available to characterize biosolids as a source and to represent it in the model is limited.

For model characterization, jurisdiction-specific data on biosolids application were used. Land uses receiving biosolids include crops and pasture/hay, with different monthly proportions based on seasonal growing patterns. Modeled application rates are the same as manure because biosolids are applied to land in the same fashion as manure.

For additional information related to representation of biosolids in the Bay TMDL, see the Phase 5.3 Chesapeake Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

Chemical Fertilizer

Chemical fertilizer application practices across the watershed can be estimated through commercial sales information. Fertilizer sales data are prepared by the Association of American Plant Food Control Officials on the basis of fertilizer consumption information submitted by state fertilizer control offices. The consumption data include total fertilizer sales or shipments for farm and non-farm use. Liming materials, peat, potting soils, soil amendments, soil additives, and soil conditioners are excluded. Materials used for the manufacture or blending of reported fertilizer grades or for use in other fertilizers are excluded to avoid duplicate reporting. A review of commercial fertilizer sales records (from 1982 to 2007) showed that in all states, the sales are increasing. The increase can be attributed to both yield increases and increasing application. Removing the yield increases resulted in persistent increasing trends in chemical fertilizer nutrient application (except in Maryland where the trend is flat).

Model estimates of commercial fertilizer loads have been derived by back-calculating load from agricultural lands and determining the proportion of nutrient species applied from commercial fertilizer, manure, and atmospheric deposition.

As phosphorus-based nutrient management plans increase, the reliance on nitrogen fertilizer is expected to increase because less manure will be legally permitted to be applied to agricultural lands. Therefore chemical fertilizers are and will remain a significant potential source of nitrogen and phosphorus to the Bay.

4.6.2 Atmospheric Deposition

Air sources contribute about one-third of the total nitrogen loads delivered to the Chesapeake Bay by depositing directly onto the tidal surface waters of Chesapeake Bay and onto the surrounding Bay watershed. Direct deposition to the Bay's tidal surface waters is estimated to be 6 to 8 percent of the total (air and non-air) nitrogen load delivered to the Bay. The nitrogen deposited onto the land surface of the Bay's watershed and subsequently transported to the Bay is estimated to account for 25 to 28 percent of the total nitrogen loadings delivered to the Bay.

Atmospheric loads of nitrogen are from chemical species of oxidized nitrogen, also called NOx, and from reduced forms of nitrogen deposition, also called ammonia (NH_4^+). Oxidized forms of nitrogen deposition originate from conditions of high heat and pressure and are formed from inert diatomic atmospheric nitrogen (N_2). The principle sources of NOx are industrial-sized boilers such as electric power plants and the internal combustion engines in cars, trucks, locomotives, airplanes, and the like.

Reduced nitrogen, or ammonia, is responsible for approximately one-third of the total nitrogen atmospheric emissions that eventually end up as loads to the Bay. Ammonia sources are predominately agricultural, and ammonia is released into the air by volatilization of ammonia from manures and emissions from ammonia based fertilizers. Minor sources include mobile sources, slip ammonia released as a by-product of emission controls on NOx at power plants, and industrial processes.

Two types of atmospheric deposition—wet and dry—are input to the Bay Watershed and Bay Water Quality Models daily. Wet deposition occurs during precipitation events and contributes to nitrogen loads only during days of rain or snow. Dry deposition occurs continuously and is input at a constant rate daily in Bay Watershed and Bay Water Quality Models.

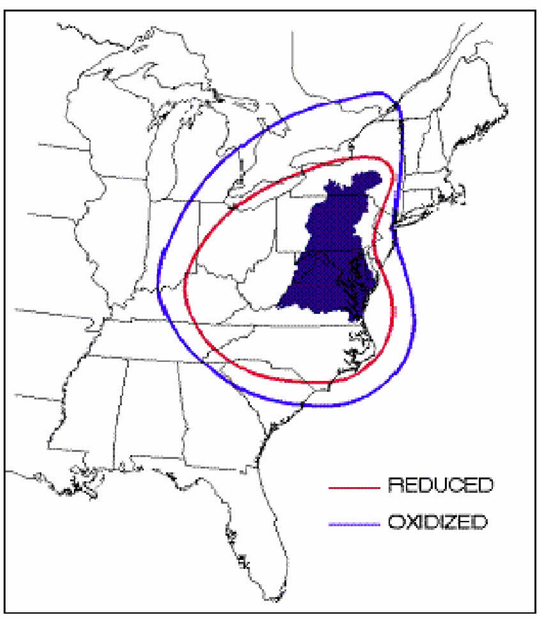
Because the Bay Watershed and Bay Water Quality Models are mass balance models, all sources of nitrogen and phosphorus inputs to the tidal Bay must be accounted for. Given atmospheric deposition of phosphorus and organic forms of nutrients are minor inputs, the Bay Watershed and Bay Water Quality Models account for estimated loads of phosphorus and organic nutrients to open surface waters only, on the assumption that all phosphorus and organic nutrients are derived from aeolian or wind processes, which result in no net change in organic nitrogen on terrestrial or land surfaces but result in a net gain when deposited directly on water surfaces.

Organic nitrogen is simulated only as wet deposition as dissolved organic nitrogen because the magnitude of dry deposition of organic nitrogen is not well characterized in the literature. Therefore, the limited dry deposition of organic nitrogen simulated by the Bay Airshed Model is lumped into the oxidized nitrogen atmospheric dry deposition.

Atmospheric deposition monitoring in the Chesapeake watershed is through National Atmospheric Deposition Program (NADP) and AirMon stations throughout the watershed. Measured deposition at these discrete stations is used to extrapolate to all the land and waters of the Chesapeake watershed through a wet deposition regression model developed by Grimm and Lynch (2000, 2005; Lynch and Grimm 2003). Dry deposition data are estimated through the Community Multiscale Air Quality Model (CMAQ) (Dennis et al. 2007; Hameedi et al. 2007) (for more details, see Section 5.4).

Chesapeake Bay Airshed

The Bay's NOx airshed—the area where emission sources that contribute the most airborne nitrates to the Bay originate—is about 570,000 square miles, or nine times the size of the Bay's watershed (Figure 4-16). Close to 50 percent of the nitrate deposition to the Bay is from air emission sources in Bay watershed jurisdictions. Another 25 percent of the atmospheric deposition load to the Chesapeake watershed is from the remaining area in the airshed. The remaining 25 percent of deposition is from the area outside the Bay airshed. The ammonia airshed is similar to the NOx airshed, but slightly smaller.

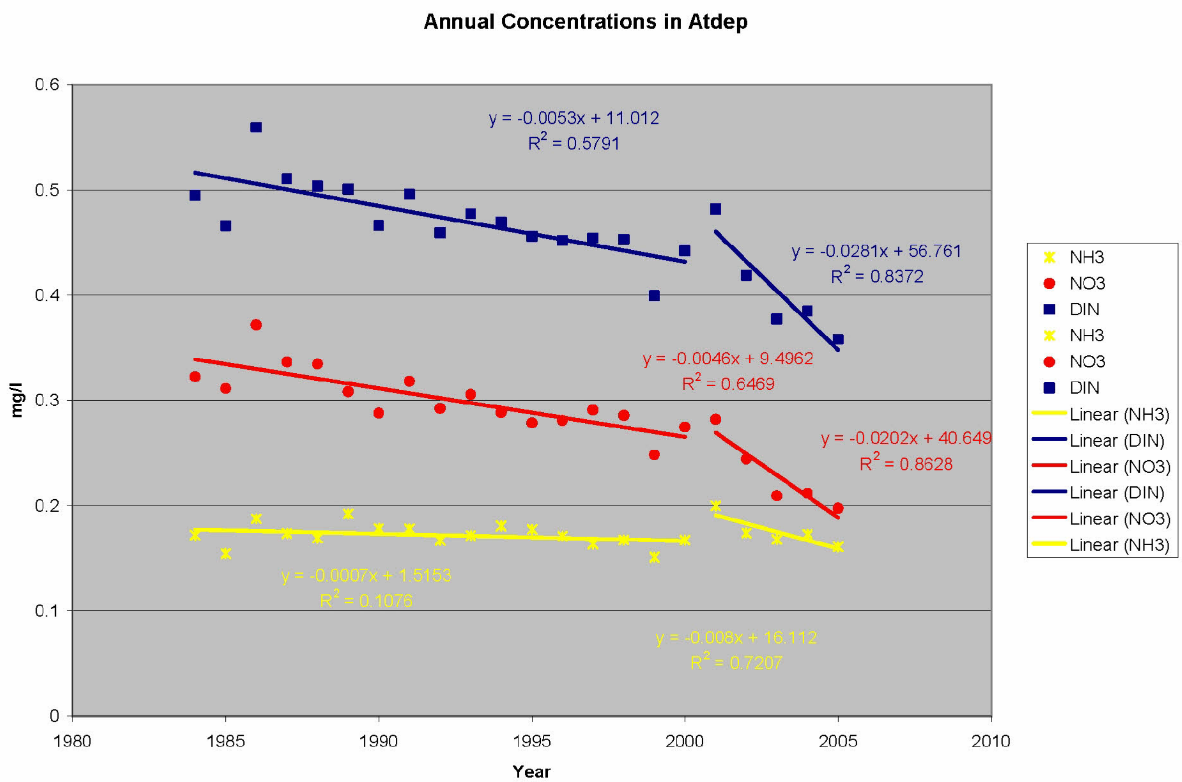


Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

Figure 4-16. Principle area of NO_X emissions (outlined in blue) that contribute nitrogen deposition to the Chesapeake Bay and its watershed (solid blue fill) (the Bay airshed).

Atmospheric Deposition Emissions Sources and Trends

Between 1985 and 2005, the simulation period of the Bay Watershed Model, atmospheric deposition loads of nitrate (NOx) in the Chesapeake watershed have decreased by about 30 percent (Figure 4-17). Considerable variability exists across the watershed, however, with the greatest reductions occurring in the northern and western portions (Grimm and Lynch 2000, 2005; Lynch and Grimm 2003). Figure 4-17 shows the trend of estimated average nitrate and ammonia deposition concentrations in the Phase 5 Model from 1984 to 2005. The average annual concentration from 1984 to 2005 was used as an adjustment to smooth out the high- and low-rainfall years, which bring different amounts of deposition load to the watershed depending on the volume of precipitation. Much of the reduction has been from point source air emission reductions, particularly from electric generating units (EGUs) such as electric power plants. Reductions from mobile sources, such as cars and trucks, are another large contributor to the downward trend.



Source: Phase 5.3 Chesapeake Bay Watershed Model.

Figure 4-17. Trend of estimated average nitrate and ammonia deposition concentrations in the Phase 5 Model domain from 1984 to 2005.

Table 4-17 shows the estimated portion of deposited NOx loads on the Chesapeake watershed from four sectors including EGUs, mobile sources, industry, and all other sources. From 1990 to 2020, considerable reductions have been made in the power sector. In addition, both on road and off-road mobile sources have ongoing fleet turnover and replacement, which is putting cleaner spark and diesel engines in service, and that is expected to continue beyond 2030. Table 4-17 shows that in 1990, EGUs are the dominant source of NOx; in 2020, mobile sources will be the dominant sources of NOx with EGUs the least contributor of NOx. However Figure 4-17 shows that all sources will be decreasing their NOx emissions, and the total deposition load in 2020 will be less than the 1990 load.

Average ammonia loads over the Phase 5 Chesapeake Bay Watershed Model domain have followed the trend in overall manure loads in the watershed and have remained steady over the 1985 to 2000 simulation period (Figure 4-17). Ammonia deposition is very site-specific and strongly influenced by local emissions. Local and regional trends in manure, such as the rise of poultry animal units in the Eastern Shore and Shenandoah basins and reduction of dairy farms in the northern portions of the watershed in the late 1980s, affect regional ammonia deposition in the Chesapeake watershed.

Table 4-17. Estimated portion of deposited NOx loads on the Chesapeake watershed from four source sectors—EGUs, mobile sources, industry, and all other sources in 1990 and 2020

Source sector	1990	2020
Power plants (EGUs)	40%	17%
Mobile sources (on-road)	30%	32%
Industry	8%	20%
Other (off-road-construction; residential, commercial)	21%	31%

Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

4.6.3 Forest Lands

Forested areas represent a significant portion of the Chesapeake Bay watershed (see Figure 2-3), as approximately 70 percent of the watershed is composed of forested and open wooded areas. This land use contributes the lowest loading rate per acre of all the land uses, however. Compared with other major pollutant source sectors in 2009, forest lands in the Bay watershed contributed an estimated 20 percent (49 million pounds per year) of total nitrogen, 15 percent (2.4 million pounds per year) of total phosphorus, and 18 percent (730,000 tons per year) of sediment of the total delivered loads to the Bay from the watershed (Bay Watershed Model 2009 Scenario).

Forest land differs from most land uses in that a significant portion of the loads that come off the land do not originate in the forests. Most of the nitrogen loads come from atmospheric deposition of nitrogen (Campbell 1982; Langland et al. 1995; Ritter and Chirnside 1984; Stevenson et al. 1987; Nixon 1997; Castro et al. 1997; Goodale et al. 2002; Pan et al. 2005; Aber et al. 1989; 2003; Stoddard 1994). Sediment and phosphorus loads originate from poorly managed forest harvesting with unprotected stream crossings and unhealthy forest biota (Riekerk et al. 1988; Clark et al. 2000).

The Bay Watershed Model differentiates between harvested and un-harvested forest lands as distinct land uses. Un-harvested forest lands contributed 1.63 lbs of nitrogen, 0.08 lb of phosphorus, and 0.02 ton of sediment per acre, which is the lowest loading rate of any land use. In contrast, harvested forest contributes 10.30 lbs of nitrogen, 0.47 lb of phosphorus, and 0.19 ton of sediment per acre. The loads from harvested forest can be greatly reduced by using forest harvesting BMPs. The loads are estimated through model calibration, which estimates loading rate per area on the basis of monitoring stations in forested areas.

For additional information related to the representation of forest lands, see the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.6.4 On-site Wastewater Treatment Systems

Onsite Wastewater Treatment Systems (OSWTS), commonly referred to as septic systems, have the potential to deliver nitrogen and phosphorus to surface waters directly because of system failure and malfunction and indirectly through groundwater. Septic systems treat human waste using a collection system that discharges liquid waste into the soil through a series of distribution lines that compose the drain field. In properly functioning (normal) systems, phosphates are adsorbed, or gathered onto the soil surface, and retained by the soil as the effluent percolates through the soil to the shallow, groundwater table. Therefore, functioning systems do not contribute nitrogen and phosphorus loads to surface waters directly. A septic system failure occurs when there is a discharge of waste to the soil surface where it is available for washoff. As a result, failing septic systems can contribute high nitrogen and phosphorus loads to surface waters. Short-circuited systems (those close to streams) and direct discharges to streams also contribute significant nitrogen and phosphorus loads.

OSWTSs represented an estimated 6 percent of the total nitrogen load from the Chesapeake watershed in 2009 (Bay Watershed Model 2009 Scenario). Information on the watershed loads from OSWTSs is generally sparse. Detailed descriptions of data procedures, source information, and assumptions used in estimating those loads are in Palace et al. (1998).

For the Chesapeake Bay Watershed Model, the number of OSWTSs in each modeling segment was estimated by calculating the number of households outside areas served by public sewer. One septic system was assumed to exist for each household. Digital maps of 2009 sewer service areas were provided by 257 of the 403 major wastewater treatment plants in the watershed contacted during a 2009 survey sponsored by EPA. Digital data were also provided by the Maryland Department of Planning for all of Maryland, Fairfax County, and the Washington Council of Governments. In 2008 the CBP Office contacted some local jurisdictions and collected sewer service area data for all three Delaware counties, Albemarle, Arlington, Henrico, Loudoun, and Rockingham counties in Virginia and for James City, Newport News City, Virginia Beach, and Richmond in Virginia. Data were also collected for Perry, Dauphin, Lancaster, Lycoming, and Cumberland counties in Pennsylvania, and for Broome County in New York. For those major wastewater treatment plants that did not provide data and were not included in data supplied by county or state agencies, the extent of their sewer service area was estimated on the basis of population density.

EPA simulated the extent of existing sewer service areas using a thresholded and log-transformed raster data set of year 2000 population density. A population density raster was created using a dasymetric mapping technique with 2000 Census Block Group data and a secondary road density raster map (Claggett and Bisland 2004). A logarithmic transformation was used to normalize the population density data in the surface raster. The standard deviations in the data range were examined to find the optimal threshold for representing sewer service areas in Maryland because statewide maps of existing sewer service areas were provided by the Maryland Department of Planning. A threshold of 1.5 standard deviations from the mean (> –0.4177) was chosen and used to reclassify the surface raster into a binary grid. A low-pass filter (ignoring no data) was then used to smooth the data, and the output was converted from a floating point to an integer grid. The resulting integer grid was used to represent potential sewer service areas for wastewater treatment plants that did not submit digital data. Households in the Bay watershed were mapped using a similar dasymetric mapping technique and 2000 Census household data. The resulting raster data set of households was overlaid on the sewer service area map to estimate the number of households outside sewer service areas. The data were scaled from the year 2000 to the year 2009 using published annual county-level population estimates adjusted for changes in average household size. In addition, the data were scaled back through time using county-level population estimates and spatially distributed raster data sets representing 1990 and 2000 Census Block Group data on the total number of households.

Using that methodology, the number of OSWTSs is estimated and the nitrate loads exported to the river from OSWTSs are simulated. Phosphorus loads are assumed to be entirely attenuated by the OSWTSs. Standard engineering assumptions of per capita nitrogen waste and standard attenuation of nitrogen in the septic systems are applied. Overall, the assumption of a load of 4.0 kg/person-year is used at the edge of the OSWTS field, all in the form of nitrate.

Using an average water flow of 75 gallons/person-day for a septic tank (Salvato 1982), a mean value of 3,940 grams of nitrogen/person-year for groundwater septic flow, 4,240 grams/person-year for surface flow of septic effluent, and typical surface/subsurface splits as reported by Maizel et al. (1995), a total nitrogen concentration of about 39 mg/L at the edge of the septic field was calculated. This concentration compares favorably with Salvato (1982) who calculated OSWTS total nitrogen concentrations of 36 mg/L. It is assumed that attenuation of the nitrate loads between the septic system field and the edge-of-river nitrate loads represented in the Bay Watershed Model is due to: (1) attenuation in anaerobic saturated soils with sufficient organic carbon (Robertson et al. 1991; Robertson and Cherry 1992); (2) attenuation by plant uptake (Brown and Thomas 1978); or (3) attenuation in low-order streams before the simulated river reach. Overall, the total attenuation is assumed to be 60 percent (Palace et al. 1998) that is applied to all OSWTS in the Bay watershed except for MD where the zone specific attenuation rates developed by MDE were used. MDE assumes an 80 percent delivery rate (or 20 percent attenuation) in critical areas; a 50 percent delivery rate within 1,000 feet from any perennial surface water; and a 30 percent delivery rate from distances greater than 1,000 feet from any perennial surface water (http://www.mde.state.md.us/assets/document/NutrientCap_Trading_Policy.pdf).

Additional information related to how the number of OSWTSs is estimated and how they are represented in the model is available in the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169

4.6.5 Nonregulated Stormwater Runoff

The sources of nitrogen, phosphorus and sediment from nonregulated stormwater are generally the same as those from regulated stormwater. Sources include residential and commercial application of fertilizer, land disturbance and poorly vegetated surfaces, atmospheric deposition of nutrients, pet wastes, and developed properties. Together with regulated stormwater, the nitrogen, phosphorus, and sediment loads affect local water quality and habitats and represent a significant proportion of nitrogen, phosphorus, and sediment loads to the Bay. The CBP estimates that, in 2009, urban and suburban development and runoff contributed to 16 percent of the sediment loadings, 15 percent of the phosphorus loadings, and 8 percent of the nitrogen loadings to the Bay (Bay Watershed Model 2009 Scenario).

The regulated sources of stormwater are discussed in the point sources section above (4.5.5). For the purposes of the TMDL, urban and suburban runoff occurring outside the NPDES regulatory purview is considered nonpoint source loading and is a component of the LA. However, note that CWA section 402(p) provides the authority to regulate many of those discharges. If any of the discharges are designated for regulation, they would then be considered part of the WLA. As discussed in Section 8 some of the unregulated sources of stormwater are being shifted from the LA portion to the WLA portion of the TMDL as potential regulated sources to further increase the reasonable assurance that the TMDL reductions will be achieved. Some jurisdictions might have state stormwater regulatory programs and, therefore, could have little to no nonregulated stormwater sources.

For additional details related to how the non-regulated stormwater runoff loads were estimated in the Bay Watershed Model, see Section 7 in the Bay Watershed Model documentation at http://www.chesapeakebay.net/model_phase5.aspx?menuitem=26169.

4.6.6 Oceanic Inputs

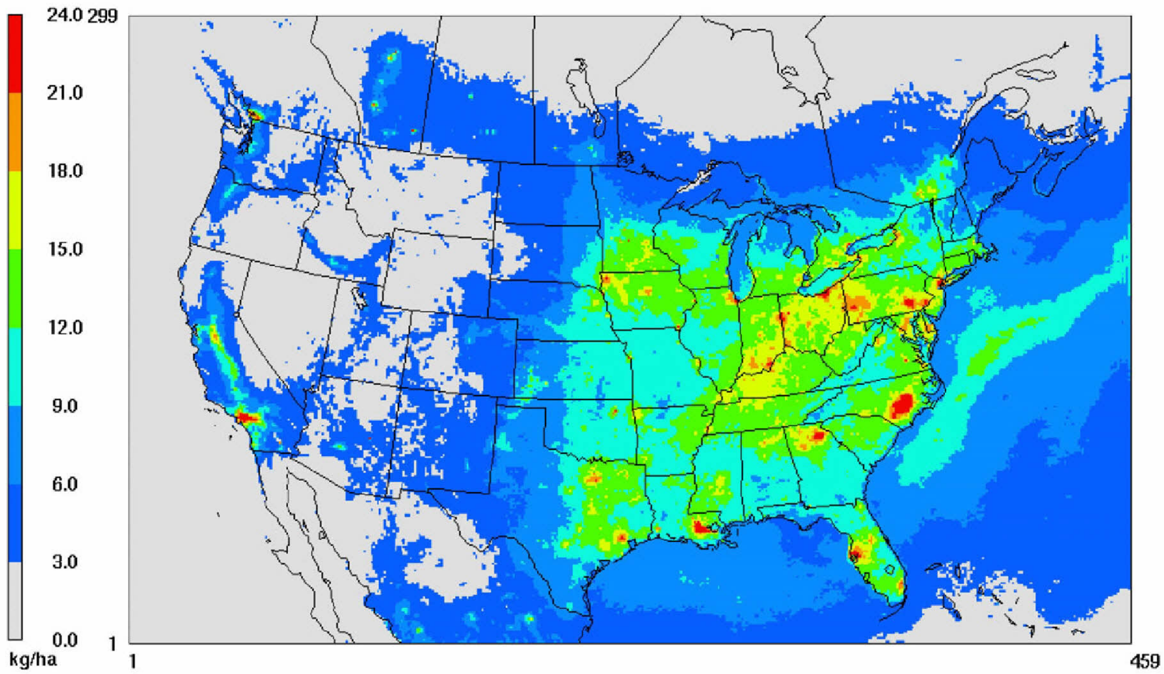
The Chesapeake Bay is an estuary and, by definition, a mixture of fresh and salt water. The relative proportion of ocean water in any region of the Bay can be roughly estimated by its salinity because salt is a perfectly conservative tracer. The salinity of full strength seawater just outside the Chesapeake Bay mouth is about 35 parts per thousand (ppt). At mid-Bay around the where Potomac River enters the mainstem Bay, the salinity drops to about 15 ppt, or a mixture of about half seawater (43 percent) and at the Bay Bridge between Annapolis and Kent Island, Maryland, salinity drops to about 6 ppt or 20 percent seawater. While nitrogen, phosphorus and sediment concentrations are relatively low in ocean water, the large volume of seawater entering the Bay brings considerable nitrogen, phosphorus, and sediment loads to the Bay.

Ocean input loads of nitrogen, phosphorus, and sediment to the Chesapeake Bay are determined by calibration to the three Bay water quality monitoring stations at the mouth of the Chesapeake Bay by using the Curvilinear-grid Hydrodynamic Three-Dimensional model (CH3D Hydrodynamic Model), which has a model grid and domain that extends about 10 km beyond the mouth of the Bay. Ocean boundary concentrations are set monthly in the Chesapeake Bay Water Quality and Sediment Transport Model (Bay Water Quality Model) to best represent the nitrogen, phosphorus, and total suspended solids concentrations of the monitoring stations at the Chesapeake Bay month on an incoming tide.

A previous study of ocean boundary loads found that when accounting for all input loads to the Chesapeake Bay, including atmospheric deposition to tidal waters and ocean inputs, the ocean inputs were significant and accounted for about one-third of the total nitrogen and about half the total phosphorus loads to the Bay (Thomann et al. 1994). Ocean sediment inputs are predominantly sand and have little influence on light attenuation beyond the Bay mouth and lower mainstem Bay.

Several nutrient budgets of the ocean waters off the Chesapeake, also called the Middle Atlantic Bight, have been made (Fennel et al. 2006; Howarth et al. 1995; Howarth 1998). Howarth (1998) estimates that for the northeast coast of the United States, which includes the discharge of all watersheds from Maine to Virginia draining to the Atlantic, the watershed inputs of nitrogen to coastal waters are 0.27 teragram (10^{12} grams) from rivers and estuaries. Estimated inputs from direct atmospheric deposition to coastal waters are 0.21 teragram, and inputs from deep ocean upwelling are 1.54 teragrams for a total input to the coastal ocean of 2.02 teragrams.

The direct atmospheric deposition loads are roughly equivalent to the watershed loads in the northeast United States. The estimated distribution of 2001 atmospheric deposition loads to North America and adjacent coastal ocean is shown in Figure 4-18. Using the Community Multi-scale Air Quality (CMAQ) Model estimates of atmospheric deposition loads to the coastal ocean under different air scenarios provides a means of adjusting the ocean boundary loads to changes in atmospheric deposition. Appendix L describes how the ocean boundary loads were adjusted to reflect projected changes in nitrogen atmospheric deposition to the coastal ocean and, therefore, coastal ocean nitrogen loads delivered to Chesapeake Bay.



Source: Dr. Robin Dennis, EPA/ORD/NERL/AMAD/AEIB

Figure 4-18. Estimated 2001 annual total deposition of nitrogen (kg/ha) to North America and adjacent coastal ocean.

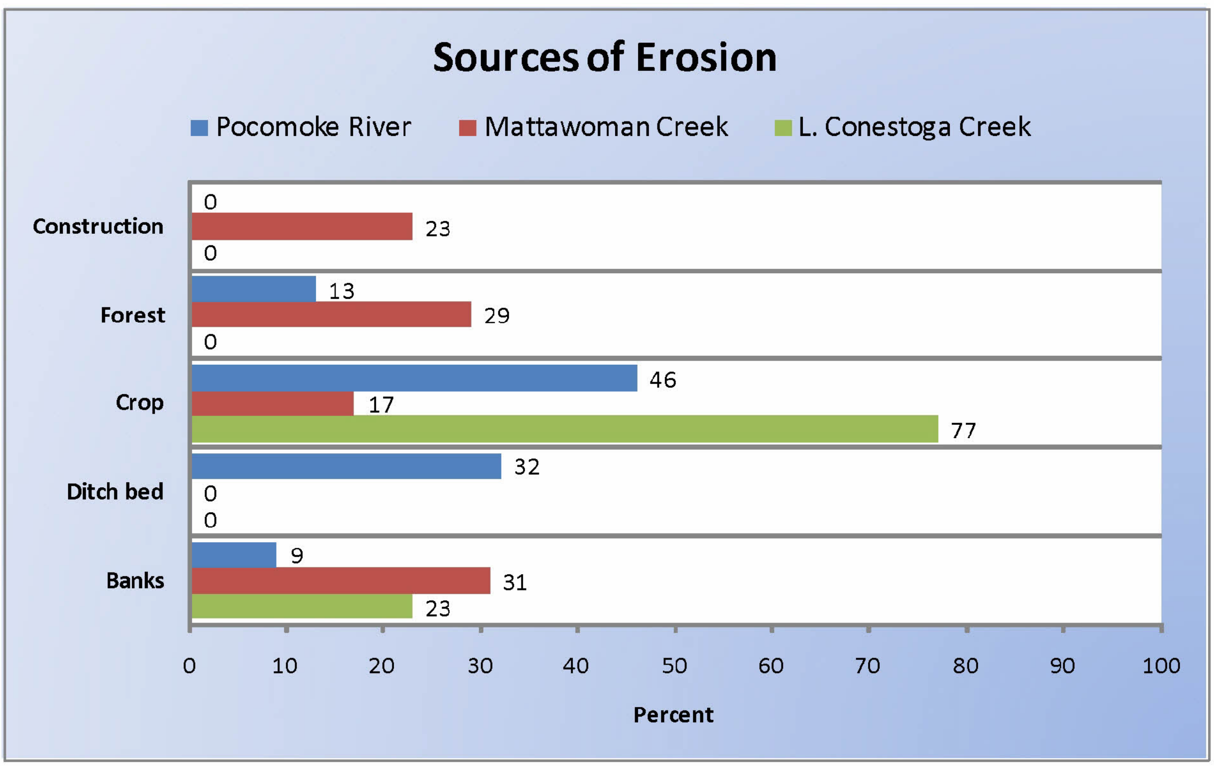
AR0000147

4.6.7 Streambank and Tidal Shoreline Erosion

Steambank Erosion

Streambank erosion is erosion from the reworking of streams and rivers, either as flow rates change as in the case of increased imperviousness in a watershed (Center for Watershed Protection 2003), because of long-term changes in the landscape (Walter and Merritts 2008; Trimble 1999), or as a natural process of river channel dynamics (Leopold et al. 1995).

In the Chesapeake Bay watershed, the relative amounts of streambank erosion and erosion from the land is difficult to quantify (Gellis et al. 2009) because the water quality monitoring stations measure the total suspended sediment in the free-flowing rivers, which is composed of sediment from both sources. The Bay Watershed Model has estimates of land erosion derived from RUSLE estimates made in the National Resource Inventory (http://www.nrcs.usda.gov/technical/NRI/), which could be used to quantify that source of sediment relative to the scour and erosion simulated in the rivers, but both sources of information are thought to be too crude to estimate the splits in erosion loads on a segment basis. However, on a watershed-wide basis, both sources of information estimate that 70 percent of the sediment delivered to the Bay comes from erosion from land and 30 percent comes from bank erosion. That is consistent with other estimates from research and field studies that find a wide variance of the portions of delivered erosion from land surfaces and bank erosion but could be generalized to about one-third of the erosion as coming from bank erosion (Figure 4-19).



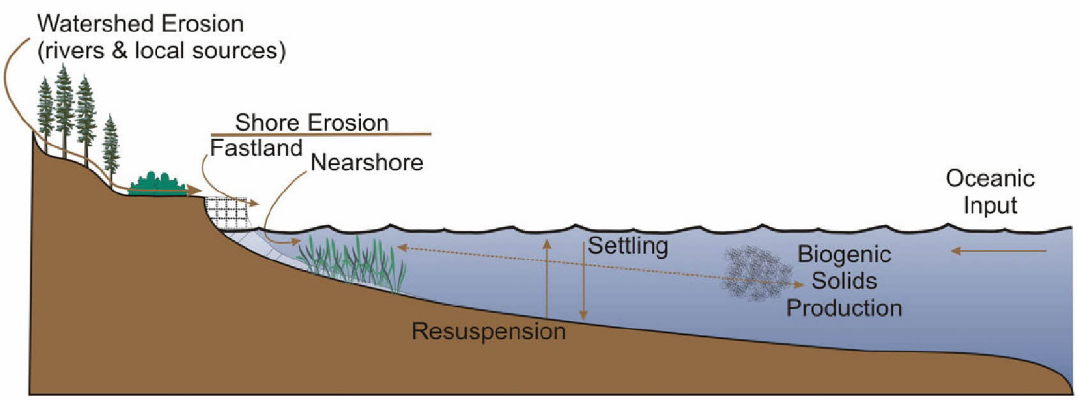
Source: Gellis et al. 2009

Figure 4-19. Relative estimates of sources of erosion from land sources (crop, forest, or construction) or bank sources banks and ditch beds).

Because sediment monitoring stations in the watershed collect all the sediment loads passing the station, including both land erosion and bank erosion sources, the stream bank load is accounted for, ultimately, both in the Chesapeake Bay watershed monitoring network and in the Bay Watershed Model, at least as part of the total combination of sediment from land and riverine sources. In the same way, streambank loads are also accounted for in tracking sediment load reductions from stream restoration actions and through reductions of nitrogen, phosphorus, and sediment tracked in the jurisdictions' WIPs.

Tidal Shoreline Erosion

Tidal shoreline erosion is a combination of the erosion of fastland (or shoreline) and nearshore erosion. Figure 4-20 illustrates the tidal shoreline erosion process. Fastland and nearshore is subtidal and usually unseen. Subtidal erosion can be accelerated when shoreline protection activities such as stone revetment, a facing of stone placed on a bank or bluff to protect a slope, are used. That practice typically cuts off fastland erosion, but the reflected wave energy continues subtidal erosion until the wave energy no longer scours the bottom to the depth of a meter or more.



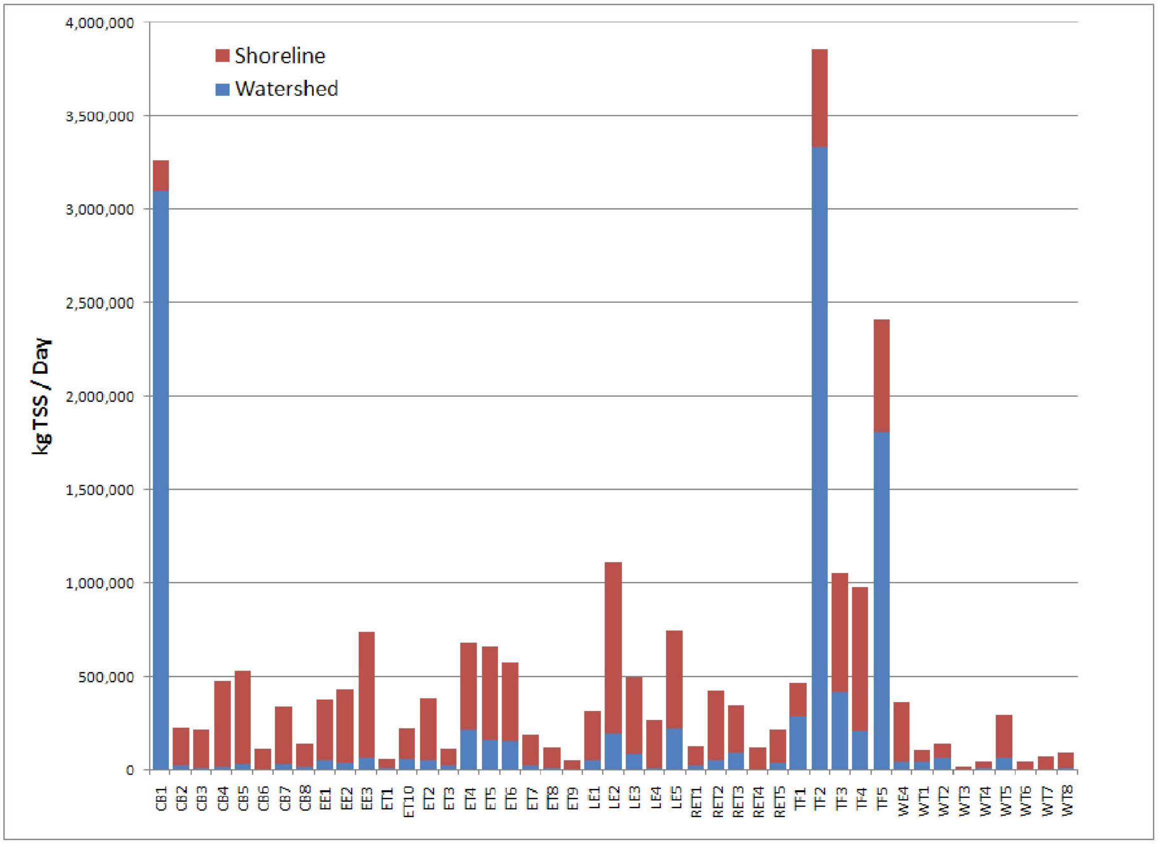
Source: CBP Sediment Workgroup

Figure 4-20. Sources of total suspended solids in the Chesapeake including the two components of shoreline erosions, fastland and nearshore erosion.

Estimates of shoreline erosion were provided for the Bay Water Quality Model. Estimates of the shore recession rate, the elevation of the fastland, and the subtidal erosion rate were used to develop the shoreline erosion estimates. Figure 4-21 demonstrates considerable variation in the sediment load delivered by sediment erosion from segment to segment.

4.6.8 Tidal Resuspension

The bottom of the Chesapeake Bay is covered by sediment that has been either carried into the estuary by rivers draining the Bay's extensive watershed; eroded from the Bay's lengthy shoreline; transported up-estuary from the Atlantic Ocean, through the mouth of the Bay; introduced from the atmosphere; or generated by primary productivity (Langland and Cronin 2003). Tidal resuspension is generated by episodic wave or current energy that scours the bottom sediment and resuspends the surficial sediment layers.



Source: Chesapeake Bay Water Quality and Sediment Transport Model.

Figure 4-21. Estimated tidal sediment inputs for 1990 from the Chesapeake Bay watershed and from shore erosion. Shoreline sediment inputs (here labeled bank load) are estimated to be about equal to watershed inputs (here labeled as nonpoint source).

In the Bay Water Quality Model, a wave resuspension model simulates such episodic events. In some regions of the Bay, resuspended sediment can be one of the most detrimental sediment loads to SAV restoration as shown in results of sediment scoping scenarios run on the Bay Water Quality Model (Table 4-18). The Bay Water Quality Model was run to compare the base scenario of the 2010 Tributary Strategy against model scenarios that individually eliminated watershed loads of total suspended sediment, fall line loads of total suspended sediment, shore erosion loads, sediment resuspension loads, and ocean sediment loads. The model scenarios were run to determine which sediment source was most important. In most of the mainstem Bay, sediment resuspension loads were relatively more detrimental to SAV growth than were other sediment sources.

4.6.9 Wildlife

Wildlife sources are rarely, if ever, considered in nitrogen and phosphorus TMDLs because wildlife only cycle nitrogen and phosphorus that already exist in the system. To the extent that wildlife increases the availability of nitrogen and phosphorus for runoff, wildlife nitrogen and phosphorus loads are inherently represented in land use sources. As a specific example, the loads

Table 4-18. Chesapeake Bay Water Quality and Sediment Transport Model -simulated SAV acres under a range of sediment scoping scenarios compared with the 2010 Tributary Strategy scenario

CBSEG	SAV acre	No watershed loads % increase over base	SAV acre	No fall line loads % increase over base	SAV acre	No shore erosion loads % increase over base	SAV acre	No resus-pension loads % increase over base	SAV acres	No ocean sed loads % increase over base
CB1TF	11,253	23%	11,001	20%	9,751	6%	10,344	13%	9,173	0%
CB2OH	212	63%	192	47%	177	36%	269	107%	138	6%
CB3MH	609	44%	539	28%	478	13%	704	67%	450	7%
CB4MH	1,150	30%	1,039	18%	1,096	24%	1,671	89%	980	11%
CB5MH	9,432	9%	9,086	5%	10,341	20%	14,055	63%	9,177	6%
CB6PH	825	21%	695	2%	701	3%	980	44%	728	7%
CB7PH	14,236	4%	13,798	1%	13,959	2%	14,582	7%	14,162	4%
CB8PH	6	25%	5	17%	5	5%	6	29%	5	18%

a. The percentages are the percentage increase in simulated SAV acres over the 2010 Tributary Strategy scenario SAV acres.

from the wooded land incorporate nitrogen and phosphorus loads that are cycled through wildlife. The overall loads from the watershed and each land use type are calibrated to observed data and literature load estimates, which also include loads cycled through wildlife. As a result, no explicit allocation to wildlife is necessary or appropriate in the Bay TMDL.

4.6.10 Natural Background

The Bay Airshed Model, Watershed Model, and Bay Water Quality Model all include the loads from natural background conditions because all the Bay models are mass balance models and are calibrated to observed conditions. For example, the atmospheric deposition loads are monitored principally at the NADP sites. The deposition measured at those sites includes NOx from natural sources, which includes lightning, forest fires, and bacterial processes such as nitrification, which oxidizes ammonia (NH_3) to NO_2 or NO_3. Those sources compose about 1 percent of the NOx deposition in the Chesapeake region (USEPA 2010i). Natural background sources of ammonia are easily volatilized from land and water surfaces and are generated from the decay (ammonification) of natural sources of organic nitrogen. Those are likewise a relatively small portion, relative to anthropogenic sources, of the atmospheric loads estimated by the NADP sites.

Natural loads of nitrogen, phosphorus, and sediment from forested land are also part of the monitored load at the free-flowing stream, river, and river input monitoring stations throughout the Chesapeake Bay watershed. Because the loads are part of the total loads to which the Chesapeake Bay Program's mass balance models are calibrated, the natural nitrogen, phosphorus, and sediment loads in the system, while small, are fully accounted for in the Bay TMDL assessment.

The natural background loads can best be estimated by simulating the All Forest scenario, which includes no point source, manure, or fertilizer loads. Atmospheric deposition loads in that scenario are set at estimated pristine levels. The scenario yields delivered nitrogen, phosphorus, and sediment loads that are more than an order of magnitude less than current conditions (see Appendix J).